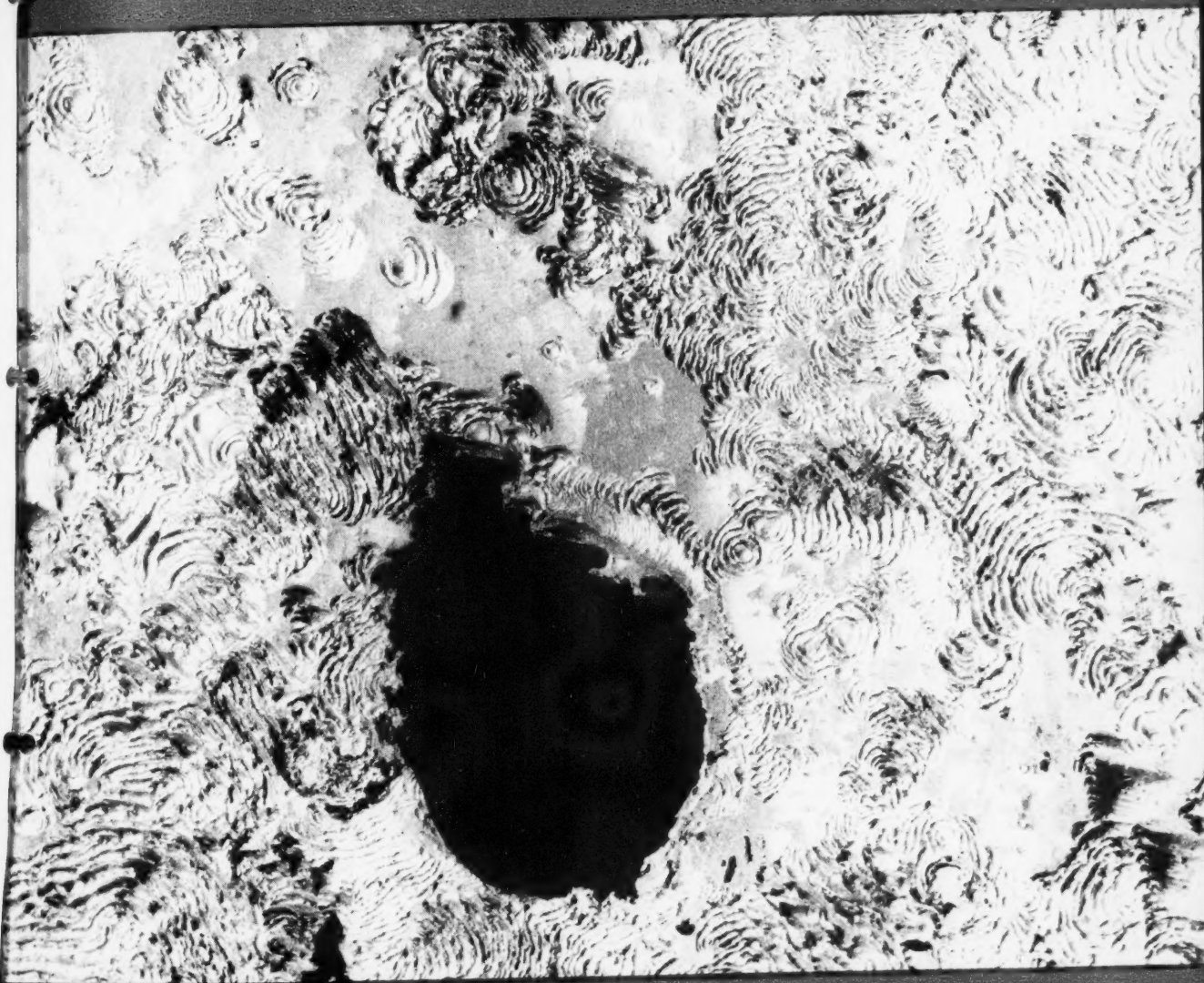


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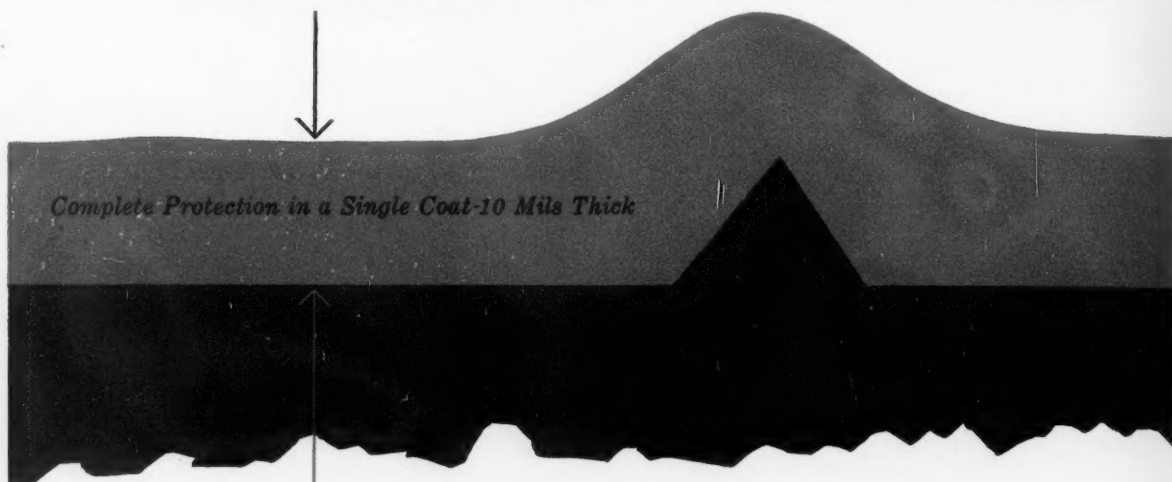
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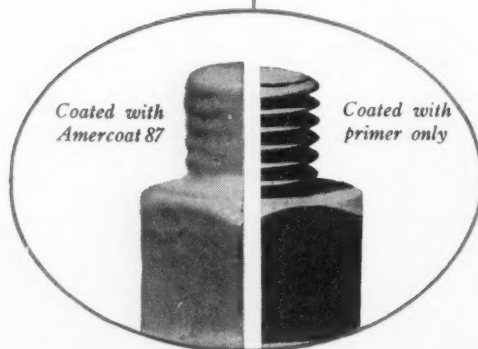
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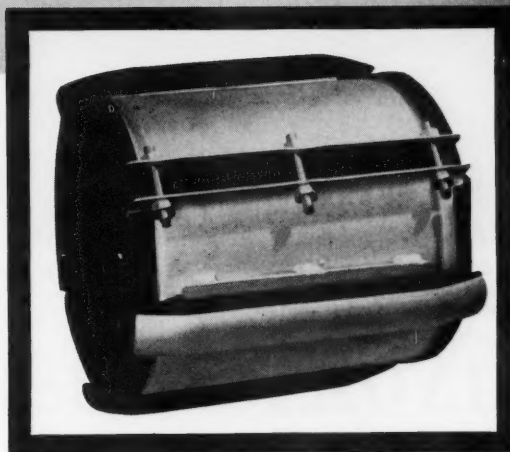
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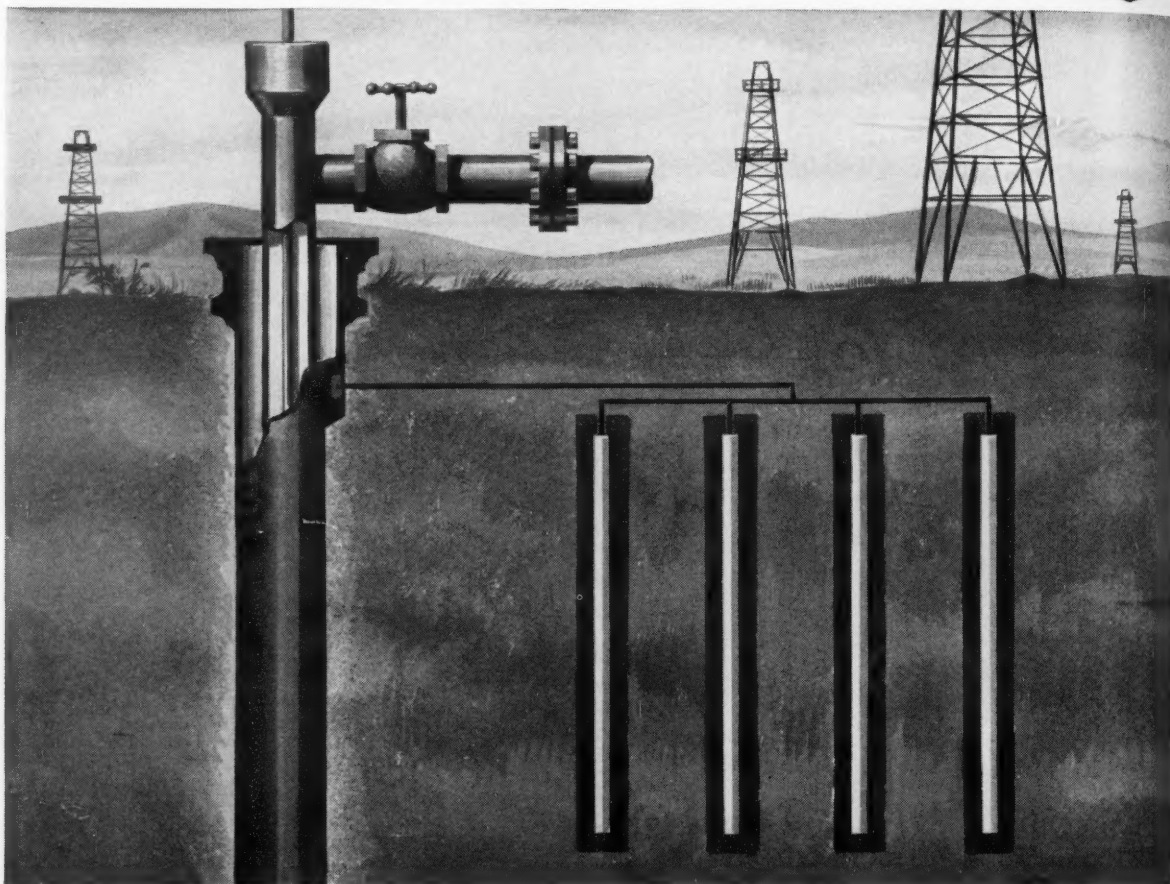
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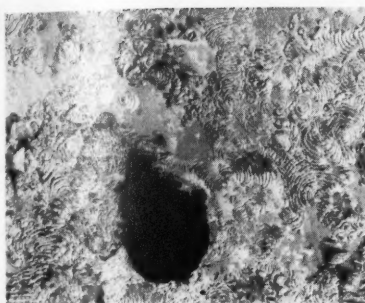
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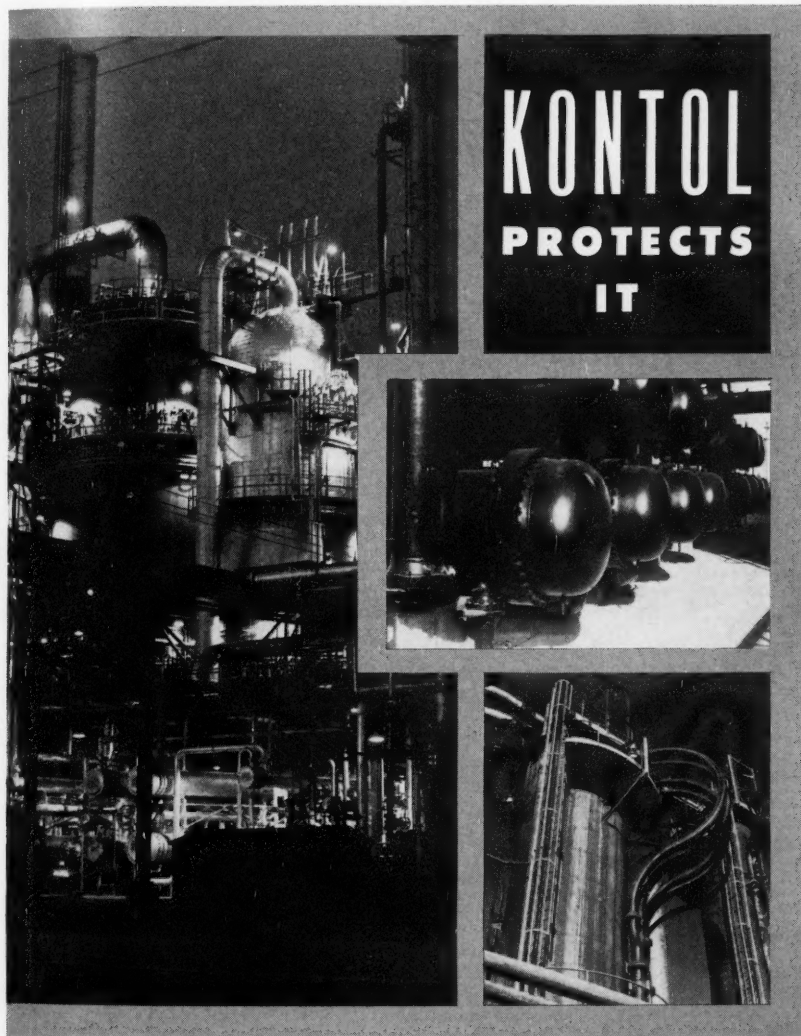
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(Continued on Page 8)



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Copies of back issues of Volume 11, January-December, 1955 are available except July. Persons who customarily bind all or parts of Corrosion and who lack issues to make the volume complete may get back copies at the following prices per copy, postpaid, remittance in advance: NACE members, 50 cents; Non-members, \$1. An additional charge of 65 cents per package is made for mailings to addresses outside the United States, Canada and Mexico.



Brothers, and officers of the A. T. Switzer Co.—Leon (left) and Ralph Switzer at Kansas City Stadium. Switzer painters sprayed stadium in six weeks.

Leon and Ralph Switzer state their case for spray painting

The DeVilbiss spray method saves time and labor, creates more jobs for painters, improves painting results

"In 35 years' experience in commercial and industrial painting, we've seen many changes and advances in our industry," says Leon Switzer, President of the A. T. Switzer Company, Kansas City, Mo. "The most significant has been that of the spray method. With the new lacquers, plastics, epons, polyvinyls—it has literally become a necessity.

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Residential painting speeded

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Use DeVilbiss spray wherever possible

"All our spray equipment is DeVilbiss . . . we use it on

every job that we can. Its trouble-free operation is part and parcel of our reputation, both industrially and commercially. We consider DeVilbiss the stand-by of the spray method, and believe the use of spray will expand to more and more jobs in the coming years. In fact, each year we send new employees to DeVilbiss' tuition-free spray school for training."

Why don't you benefit with DeVilbiss!

DeVilbiss not only offers a complete line of spray guns, hose and connections, paint tanks, compressors, and accessories—but also practical training in the spray method of which Mr. Switzer speaks. Whatever type painting you do, call your DeVilbiss jobber for information.

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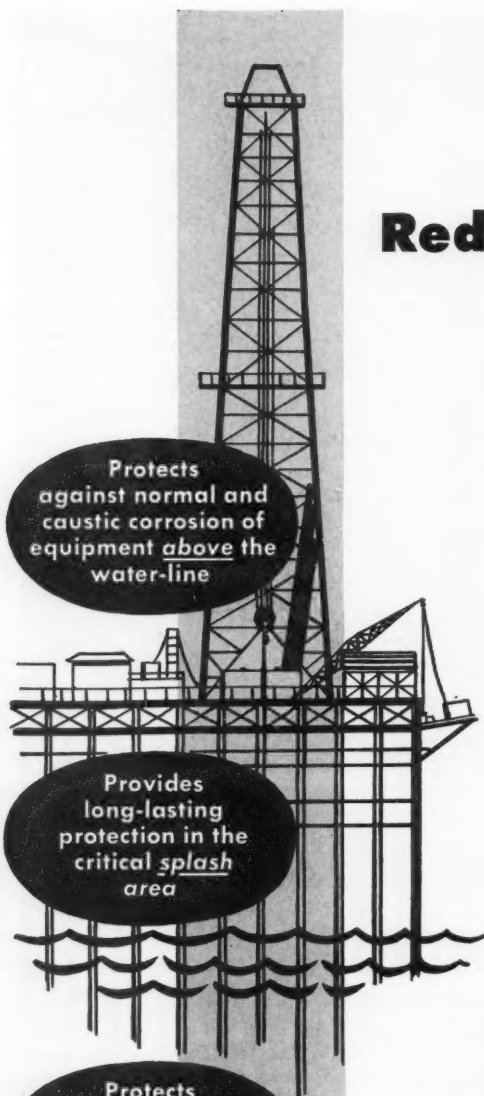
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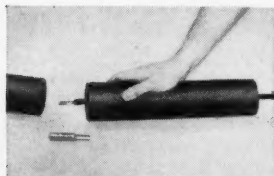
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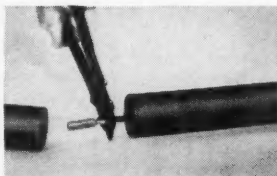
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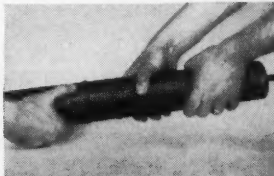
Here's how simple assembly is:



Strip one end of connecting cable and insert thru 15" top anode section.



Join connector to cable end using crimp or solder-type connector.

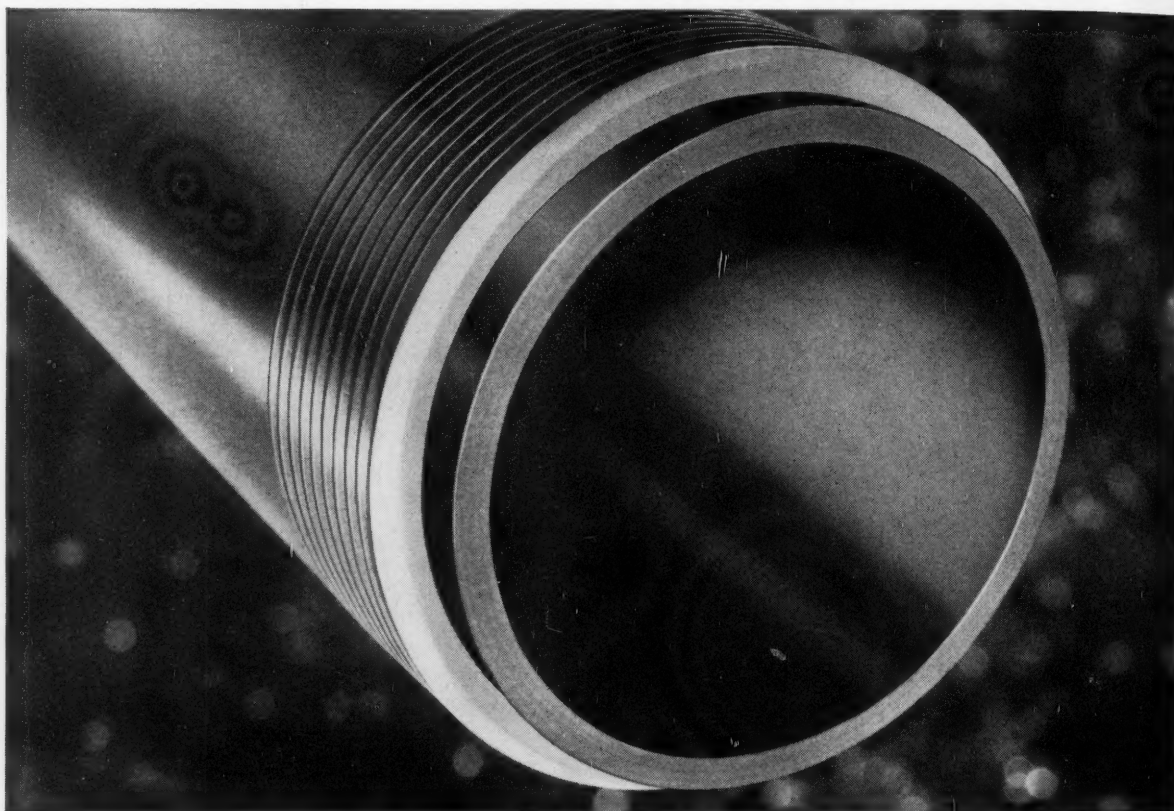


Cement and join anode sections as illustrated in above photo.

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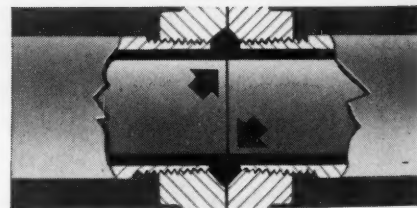
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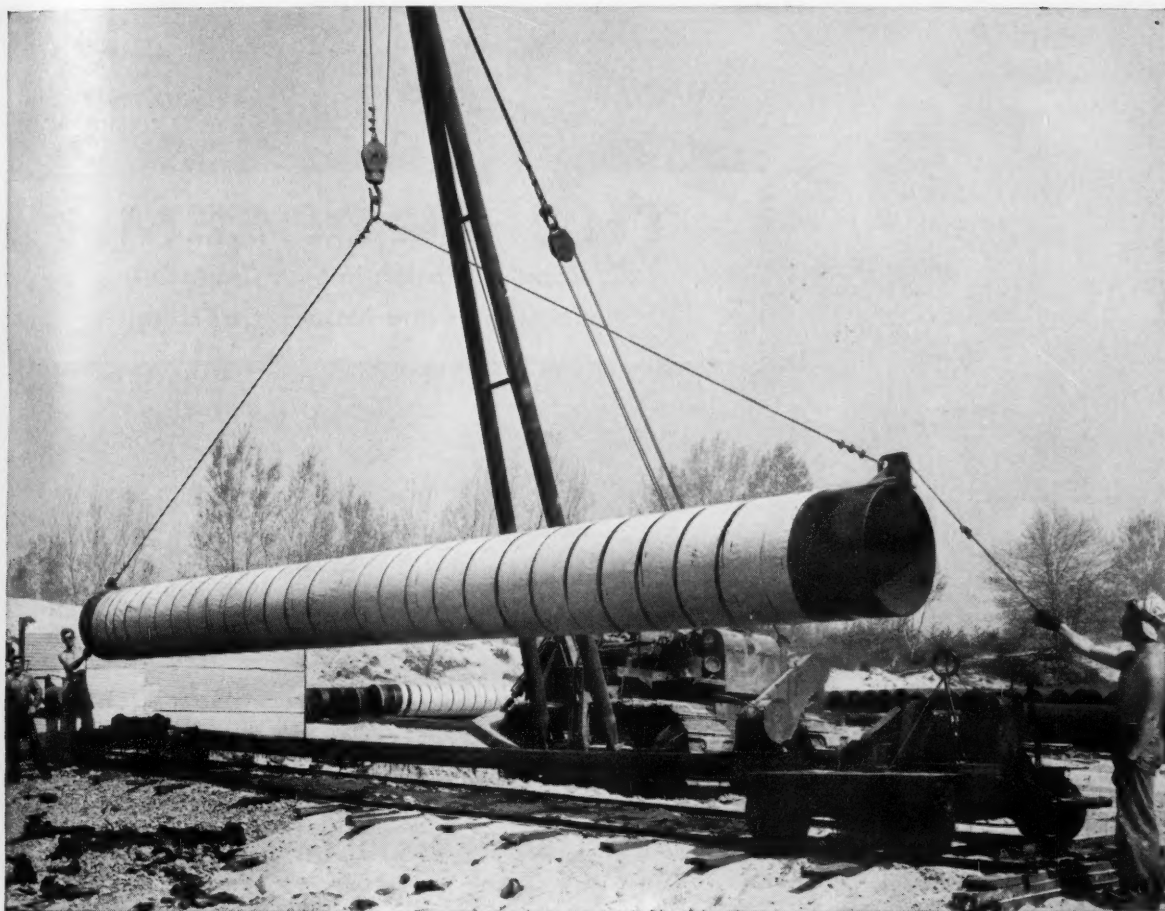
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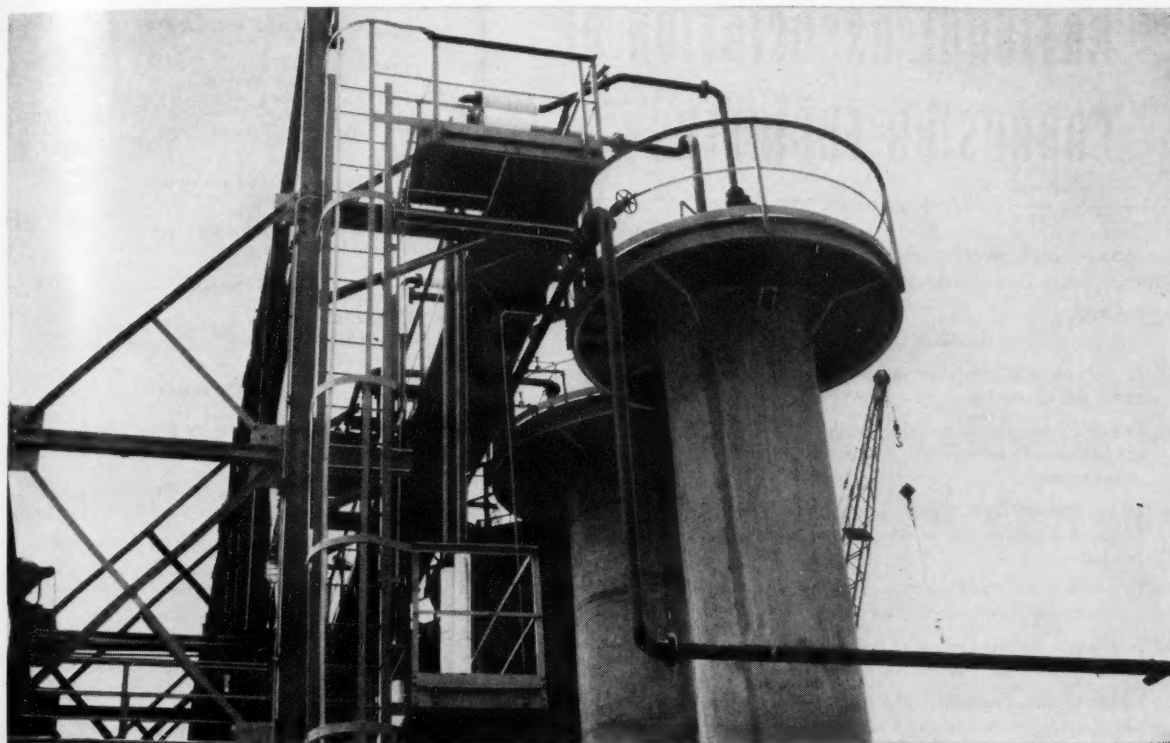
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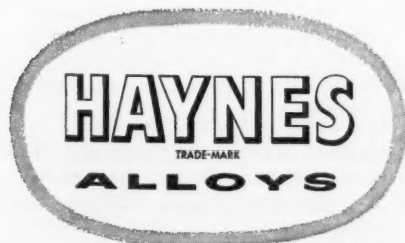
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is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
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- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of memberships, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.



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Topic of the Month

Corrosion in Caustic of Nickel-Iron Welds Obtained in Fabrication of Nickel-Clad Vessels

By PAUL J. GEGNER*

Introduction

PRELIMINARY STUDIES indicate that appreciably more iron can be tolerated in the welds of nickel-clad vessels to be used in caustic soda service than has been permitted heretofore in most specifications.

Conventional welding of nickel-clad equipment calls for the use of an appropriate steel electrode with the steel side being welded first. The root bead should fuse to the base of the steel but should not penetrate into the nickel. Penetration of the steel root bead into the nickel may form a hard, brittle alloy which is difficult to back chip and may later result in cracking of the weld. Accurate fitting of the plate edges and proper bevelling are important in controlling this penetration.

After the steel side is welded, the clad side is chipped or ground to clean, sound weld metal. For caustic service, the clad side welding is done entirely with a straight nickel electrode. To reduce iron in the weld, the top half of the nickel root bead is chipped or ground off before succeeding layers of weld metal are deposited. To further reduce the amount of iron, stringer beads from small diameter rods are used. The greater the number of layers, or the greater the extent of back chipping, the lower will be the iron content in the exposed layer of weld metal.

The taking of these precautions against iron contamination of nickel welds has resulted in high fabrication costs for nickel-clad vessels. It also has limited the use of lighter grades of nickel-clad steel, such as the 5 percent and 10 percent clads.

Field Exposure Tests

Field exposure tests in 73 percent caustic soda at

250 F were conducted on: (1) nickel specimens made up with nickel weld deposits containing varying amounts of iron from 0 to 23 percent iron; (2) solid coupons of nickel and iron compositions containing up to 20 percent iron; and (3) a small test vessel fabricated from $\frac{3}{8}$ inch, 5 percent nickel-clad steel in which twelve types of nickel and nickel-alloy welds were used. The nine nickel welds in the test vessel contained from 11 percent to 38 percent iron.

Results of the coupon tests are shown in Tables 1 and 2. These data show the corrosion rates to be essentially the same in both tests, irrespective of the iron content.

The 5 percent nickel-clad vessel has been in service in 73 percent caustic at 250 F for $3\frac{1}{2}$ years. The

TABLE 1—Corrosion of Iron-Contaminated Nickel Welds in 73 Percent Caustic at 250 F.

Percent Iron In Weld	CORROSION RATE—Mils per Year		
	1st Exposure (30 Days)	2nd Exposure (60 Days)	Total Exposure (90 Days)
0.51.....	8	5	6
5.56.....	8	5	6
11.43.....	7	5	5
13.15.....	7	4	5
17.62.....	7	5	5
22.85.....	6	4	5

TABLE 2—Corrosion of Nickel and Nickel-Iron Alloys in 73 Percent Caustic at 250 F.

Percent Fe	Corrosion Rate—Mils per Year
0.....	7
0.....	7
5.....	8
5.....	8
10.....	6
10.....	8
20.....	8
20.....	8

* Columbia-Southern Chemical Corporation, Barberton, Ohio.

nickel weld with 38 percent iron has been visibly corroding. The remaining nickel welds containing up to 25 percent iron show neither corrosion nor cracking.

Some independent work by the International Nickel Company supports the conclusion that up to 20-25 percent iron dilution does not affect appreciably the corrosion rate of nickel in caustic. Their test, conducted in 75 percent caustic at 262 F for 7 days,

also showed no significant acceleration of corrosion caused by galvanic couples between nickel and nickel diluted with varying amounts of iron.

These tests indicate that in nickel-clad vessels for caustic service, iron can be tolerated in the welds up to about 25 percent, insofar as corrosion is concerned. Additional work is being planned to evaluate the effects of iron on the stress cracking susceptibility of nickel welds in caustic service.

DISCUSSIONS ON TECHNICAL ARTICLES ARE SOLICITED

Discussions on technical articles published in *Corrosion* will be accepted for review without invitation. Discussions must be constructive, accompanied by full substantiation of fact in the form of tables, graphs or other representative data and be submitted in three typewritten copies.

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Part 1 of 2 Parts

Corrosion Testing of Aluminum*

Part 1—High Velocity Test Method in Aqueous Solutions

By SUMNER B. TWISS and JACK D. GUTTENPLAN

Introduction

ALUMINUM HAS an inherently high resistance to corrosion in aqueous solution because of the formation of a protective oxide film. Even so, pores or breaks in this film are points where localized corrosion and pitting may begin. Pitting can lead to perforation of parts, particularly where thin metal sections are used. Sacrificial zinc-aluminum cladding (Alclad) has been used on thin aluminum parts to distribute corrosive attack over a larger area and thus reduce the potential of the base metal to corrode. Actually, however, even this clad material is susceptible to eventual pitting attack and perforation after removal of the cladding from large areas of the surface.^{1,2} For this reason corrosion inhibitors have become an important factor in the use of aluminum with aqueous solutions.

The purpose of this paper is to present a new type of high velocity test used in determining corrosion characteristics and in screening corrosion inhibitors for aluminum in aqueous solution. The test was developed in the company's laboratory as part of a major testing program on aluminum radiators.

Because the attack on aluminum by uninhibited tap waters and synthetic waters (dilute salt solutions) is such a slow process, it is difficult to evaluate the relative effectiveness of inhibitors in these solutions. This is particularly true in circulating type bench tests of radiators and full scale fleet testing of radiators in automobiles. Both of these tests may require many months or years for completion. To reduce this time factor in the preliminary screening of inhibitor effectiveness, an accelerated laboratory test was designed—the acceleration stemming from high velocity movement (high speed of rotation) of the test specimen.

Many accelerated tests have been set up in the past where the concentration of one of the components of the corrosive medium has been increased or elevated temperatures used to obtain a faster corrosion rate. It is generally recognized today that application of the results of these tests to the much slower corrosion processes involved in service performance of parts is extremely risky, unless a prior correlation has been established between the accelerated test and performance.

The same criticism applies to the use of increased velocity of movement of the test specimen or of the corrosive medium to obtain faster corrosion. It is



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Abstract

A technique of corrosion testing, involving spinning of aluminum disks in aqueous solutions at high velocities, was used to investigate the effect of various natural waters and antifreezes on aluminum corrosion. Type of aluminum used was No. 100 aluminum brazing sheet, having zinc-aluminum cladding on one side, and silicon-aluminum cladding on the other. It was established that an increase in velocity of movement up to a maximum peripheral velocity of 4700 feet per minute (12,000 rpm) is accompanied by a systematic increase in corrosion rate reaching very high values in some waters. Type of corrosion occurring at higher velocities is similar to that occurring at low velocities and in service. Aqueous solutions particularly corrosive were those combining high chloride ion concentration and high alkalinity (as OH^- or CO_3^{2-} ion), such as Royal Oak, Michigan, tap water. High alkalinity (up to pH 11) appears to cause severe attack of aluminum even in the absence of chloride ion.

In permanent antifreeze solutions, Royal Oak tap water—ethylene glycol (1:1), an increase in velocity appeared to reduce an induction period that occurs before rapid corrosive attacks sets in. In Royal Oak tap water—*isopropyl alcohol* solutions, velocity had no effect, corrosion remaining low at all velocities for the 200 hour test. Ethylene glycol appeared to accelerate corrosion and alcohols to reduce corrosion in all waters tested.

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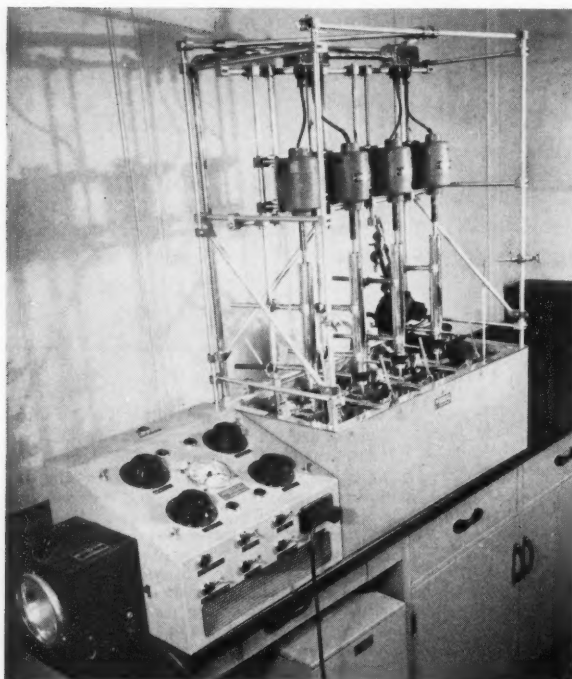


Figure 1—Chrysler test rack for high velocity corrosion testing (oil bath type). Motor and heater controls are mounted in the panel at left, together with a Strobosc for measuring motor speeds.

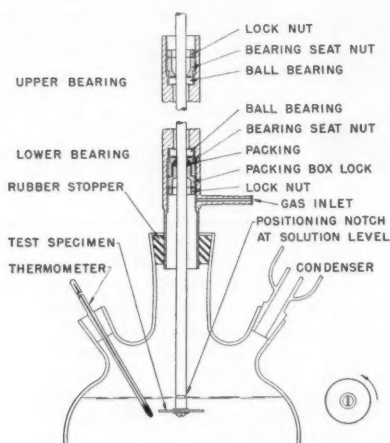


Figure 2—High-speed stirring unit showing construction of bearing housing and positioning of test specimen.

true that several such tests have been proposed and are being used.^{3,4,5,6,7} However, the velocity range generally used by investigators studying this effect has been restricted to relatively low values. Nothing appears to have been published on the effect of high velocities of movement, up to 4700 feet per minute, as reported here. For this reason considerable information on the use of high velocities to accelerate corrosion was accumulated by the authors. It was found that the following patterns hold true in general for aluminum:

1. An increase in velocity of movement up to

4700 feet per minute in aqueous solutions is accompanied by a large increase in corrosion rate.

2. The type of corrosion occurring at the higher velocities is similar to that occurring at low velocities and in service.

From these observations, it was concluded that the use of high velocity of movement to accelerate the corrosion of aluminum was acceptable.

A major premise of design is that the material should be able to withstand the most severe conditions likely to be encountered in service. For this reason, a study was made of the effect of various natural and synthetic waters on the attack of aluminum. The most corrosive water from this study was selected for use in an accelerated screening test for inhibitors which will be described later.

Experimental

Apparatus and Description of Method

The apparatus, as shown in Figures 1 and 2, consists of four high-speed stirring units mounted above a double wall insulated oil bath. Each stirring unit, similar in design to that described by A. A. Morton,⁸ has the following parts:

1. A $\frac{1}{8}$ horsepower variable-speed motor, Dumore type KB, rated at 14,500 rpm with no load.
2. A $\frac{3}{8}$ inch diameter stainless steel shaft threaded at one end to hold the test specimen.
3. A bearing housing assembly containing two ball bearings in which the shaft rotates, a packing box to prevent escape of gases up through the clearances around the shaft, and a gas inlet tube.
4. A three-neck, 500 ml Morton flask with ribbed sides. A thermometer and condenser for the side necks of this flask.

The oil bath was designed to maintain a constant temperature (± 1.0 F) in the reaction flasks of the four units. This was accomplished by means of an aminco bimetallic thermoregulator which actuates a mercury relay switch connected to a 1000-watt flexible immersion-type oil heater. These parts were all obtained from the American Instrument Company.

The test method consists essentially of rotating the specimen (machined into the form of a disk) at high speeds (12,000 rpm) in an aqueous solution. The specimen spins in a horizontal plane about an axis through its center. This rotational speed can be translated into a linear velocity, maximum or peripheral values of which amount to 4712 feet per minute at 12,000 rpm. The average velocity (of the average exposed radius) is 3142 feet per minute at this rotational speed.

Simple rotation of test specimens in a liquid is not ideal because the liquid tends to move with the specimen, reducing the relative motion between the two. Use of a Morton flask⁸ with ribbed sides, however, causes the liquid to move outward and up along the sides of the flask and to tumble down onto the top

surface of the specimen. The resulting increase in turbulence causes large volumes of air to be drawn into the solution. At the high velocities (5000 to 12,000 rpm) an increasingly high degree of aeration results, eliminating oxygen diffusion and differential aeration effects. The high turbulence also causes high shearing forces across the specimen surface which tend to lift off and remove from the surface any non-adherent corrosion product film.

Reproducibility

From duplicate tests run under various conditions during the course of this investigation and from tests repeated subsequently, the following conclusions can be reached on the reproducibility of the method:

1. In 39 tests run under 18 varied conditions both in the presence or absence of inhibitors, and wherein the total weight loss per test specimen was below 200 mg, the reproducibility was good. Under these conditions the average deviation from the mean weight loss for duplicate tests amounted to only 2.4 mg. These results are reported in actual weight loss units rather than percentage deviation. This is done because the latter units could be misleading, particularly in the inhibited tests of low weight loss, where 2.4 mg could represent 100 percent deviation.
2. In tests where the specimen failed before the end of the run (i.e., the weight loss was over 200 mg) there is no standard time for comparison of weight loss; therefore, reproducibility is reported in average deviation from the mean time of failure for duplicate tests. In eleven tests run under five different conditions this amounted to 8.6 hours, the average length of these eleven runs being 141.5 hours.
3. The natural waters used varied slightly in composition over the course of the investigation (the analyses given in Table I are average values) and the uninhibited ethylene glycol solutions gave somewhat erratic results between different batches. Therefore when tests were repeated at later dates, using different batches of the same water or anti-freeze, the reproducibility was somewhat less than shown in 1 and 2 above. For 56 tests run under 24 different conditions where the weight loss of the specimen was less than 200 mg, the average deviation from the mean weight loss now amounted to 7.2 mg. When the specimen failed during the run for twelve duplicate tests made under three varied conditions using different batches of the same water, the average deviation from the mean time of failure was 26.5 hours. Where different batches of uninhibited ethylene glycol were used, the average deviation amounted to 134 hours for five tests. The erratic results using ethylene glycol have been attributed to variation in the length of an induction period preceding corrosion. After this preliminary induction period, the rates of attack by the glycol in the five tests were very similar.

Procedure

Test specimens in the form of 1½ inch diameter disks were degreased with petroleum ether and weighed on an analytical balance. Then they were insulated on both sides by ½ inch diameter rubber washers and attached to the shafts of high speed stirring units. The X7272 alloy clad side, faced upward, received the full impact of aeration and turbulent flow. The 4343 alloy cladding, faced downward, received a minor amount of corrosive action. These disks were immersed to a standard depth in 200 ml of test solution contained in a Morton flask (see Figure 2). Temperature was maintained at 180 F

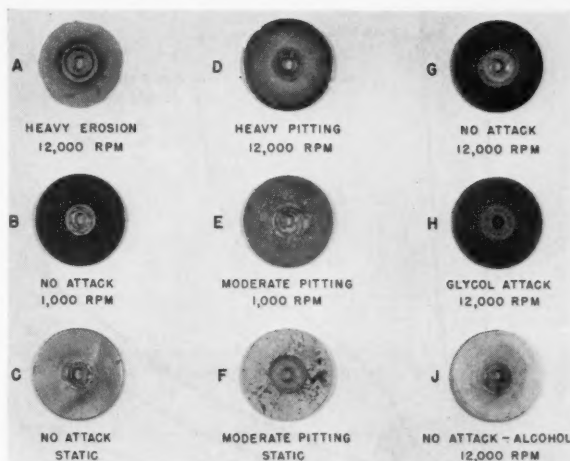


Figure 3—Various types and degrees of corrosive attack, X7272 alloy side of specimen shown. A and B: Royal Oak tap water; C and G: distilled water; D: Royal Oak tap water (522 ppm Cl, pH of 11); E and F: Royal Oak tap water (522 ppm Cl); H: Royal Oak tap water (522 ppm Cl, pH of 11)—ethylene glycol (1:1); J: Royal Oak tap water (522 ppm Cl, pH of 11)—isopropyl alcohol (1:1).

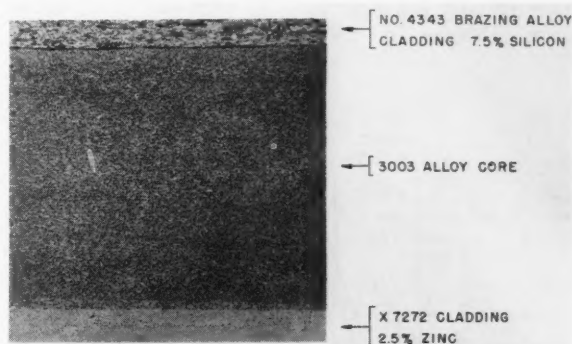


Figure 4—Cross section of No. 100 aluminum brazing sheet. Magnification approximately 30X.

(an intermediate temperature between the average winter and summer low speed driving temperature of 160 F and the maximum summer operating temperature of 235 F) by means of the constant temperature oil bath. Speed of rotation of the test specimen was controlled within 100 rpm of the desired speed with a Strobotac.

Time of the standard test was set at 200 hours or failure, whichever occurred first. Some runs which produced little corrosion were continued to 500 hours. Failure was defined as heavy pitting of the test specimen (to a depth of approximately 0.015 inch) or a weight loss exceeding 200 milligrams (approximately 5 percent of the original weight). Evaluation of corrosion was made by visual observation (pitting depth) and by weight loss measurements at specific intervals. A number of disks, selected after testing to illustrate various types and amounts of corrosion, are shown in Figure 3. While appearance of the disk is indicative of the type of attack, a plot of weight loss against time is more definitive. The majority of data is shown in such curves.

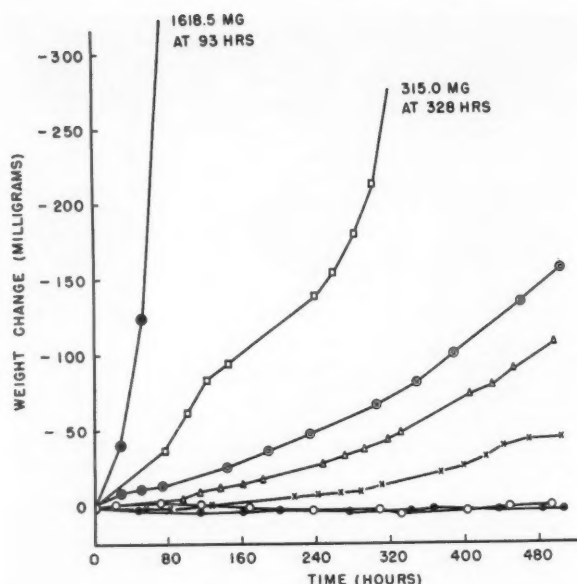


Figure 5—Accelerated corrosion of No. 100 aluminum brazing sheet in Royal Oak tap water at various speeds of rotation. ●—12,000 rpm, □—11,000 rpm, ●—10,000 rpm, △—7,500 rpm, X—5,000 rpm, ●—1,000 rpm, ○—Static.

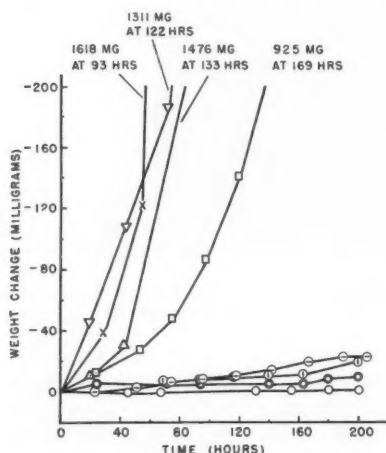


Figure 6—Corrosion test of No. 100 brazing sheet in various natural and synthetic waters at 12,000 rpm. X—Royal Oak tap water, △—Highland Park tap water (222 ppm Cl plus 218.5 ppm Na_2CO_3), □—Highland Park tap water (218.5 ppm Na_2CO_3), ●—Highland Park tap water, ●—Highland Park tap water (222 ppm Cl plus 168 ppm NaHCO_3 plus 12 ppm Na_2CO_3), ●—Highland Park tap water (222 ppm Cl), ○—Distilled water.

Materials

Number 100 aluminum brazing sheet (formerly No. XA30 brazing sheet), produced by the Aluminum Company of America, was used in this work. A cross section of this material in the "as-fabricated" condition is shown in Figure 4. The material consists of a 3003 aluminum alloy core, with a 15 percent (of

the total thickness) cladding of X7272 alloy on the water side (as exposed in the radiator) and a 10 percent cladding of 4343 alloy on the brazing side. The X7272 alloy consists of 2.5 percent zinc-97.5 percent aluminum; the 4343 brazing alloy is 7.5 percent silicon-92.5 percent aluminum.

Maximum limits of various impurities in the 3003 alloy core are as follows: Copper—0.2 percent, iron—0.7 percent, silicon—0.6 percent, manganese—1.0 to 1.5 percent, zinc—0.1 percent, total other elements—0.15 percent, aluminum—remainder. In general, silicon, iron, copper, and other impurities total about 0.7-0.9 percent. Test samples were cut from 0.051 inch sheet in the "as-rolled" condition and were not subjected to a brazing operation.

Synthetic waters were made up using Highland Park, Michigan, tap water or Royal Oak, Michigan, tap water (see Table 1 for analyses) as a base and with the addition of the following chemicals to provide the ions or action as indicated:

1. Sodium chloride (reagent) was added to increase the chloride ion concentration.
2. Sodium carbonate (reagent) or sodium bicarbonate (reagent) was used to increase carbonate or bicarbonate alkalinity.
3. Sodium hydroxide (reagent) and hydrochloric acid (reagent) were used, respectively, to raise and lower the pH of the solutions.
4. Laboratory stocks of ethylene glycol (technical), methyl alcohol (technical), and isopropyl alcohol (98 percent) were used to make up antifreeze solutions.

Results and Discussion

Effect of Velocity of Rotation

The accelerated corrosion test described in the preceding section has as its basis the large increase in corrosion rate of aluminum in aqueous solutions with high velocities of rotation. Lack of experience with the No. 100 aluminum brazing sheet, however, necessitated a preliminary study to prove the validity of the method for this material.

The effect of velocity of rotation on the corrosion rate of the clad aluminum was determined in two natural and six synthetic waters (Figures 5, 6, 7, and 8). The first increase in velocity of rotation

TABLE 1—Analyses of Natural Waters Used in Tests

MATERIAL	Highland Park Michigan Tap Water (ppm)	Royal Oak Michigan Tap Water (ppm)
Total Solids.....	125.0	377.0
Iron.....	0.0	0.2
Aluminum.....	1.0	0.7
Silica (as SiO_2).....	1.8	18.0
Sulfate.....	17.6	0.0
Chloride.....	8.0	53.0
Calcium.....	28.0	37.0
Magnesium.....	8.0	14.0
Sodium (by difference).....	2.2	97.0
Total Hardness (as CaCO_3).....	102.0	202.0
Total Alkalinity (as CaCO_3).....	78.0	280.0
Carbonate Alkalinity (as CaCO_3).....	0.0	12.0
Bicarbonate Alkalinity (as CaCO_3).....	78.0	268.0
Free Carbon Dioxide.....	2.0	4.0
pH.....	7.3	8.2

from static conditions to 1000 rpm had little effect on the weight loss of test specimens except in those waters combining high alkalinity and high chloride ion concentration. High velocities on the order of 12,000 rpm, however, increased the rate of corrosion in all waters.

A more detailed study of the effect of velocity of rotation on the amount and type of corrosion of No. 100 brazing sheet was made in Royal Oak tap water. Results of this study are shown in Figure 5. Under static conditions and at a velocity of 1000 rpm, little weight loss occurred. The only visual effects were some evidence of pits initiating in localized anodic areas under both conditions and the formation of a dark film at 1000 rpm (disk B in Figure 3). Previous investigators¹ have found dark films similar to the one just described to consist of finely etched aluminum metal.

From 1000 to 10,000 rpm, the increase in weight loss was gradual. Visually, the localized pitting became more severe, particularly near the periphery of the test disks where linear motion was the greatest. Above 10,000 rpm weight loss increased rapidly to very high values. At all velocities, corrosion appeared to start with localized pitting. At the higher velocities, these localized pits spread out through the zinc-aluminum cladding, and, when that had been consumed, attacked the 3003 aluminum alloy core with resulting erosion (see disk A, Figure 3).

Corrosion by Natural and Synthetic Waters

Prior to selecting the final conditions of test for screening inhibitors, it was necessary to determine the corrosion characteristics of the clad aluminum in various aqueous solutions that might be encountered in service at the high velocities proposed. From these data the most severe conditions could be selected for the accelerated test. Accordingly, test disks of the No. 100 aluminum brazing sheet were tested at 12,000 rpm. Tests were run both in distilled water and the natural waters available (i.e., Royal Oak and Highland Park, Michigan, tap waters). Various ions or materials were then added to these natural waters to increase attack. Results of the tests are shown in the weight change vs time curves of Figure 6 and the bar graph of Figure 7.

Attack of the clad aluminum in distilled water was negligible, the only effect being the formation of a dark film (Figure 3, disk G). The sample after exposure probably had a finely etched surface as described before. In Highland Park tap water a very localized pitting occurred, accompanied by a low weight loss. This localized pitting decreased in severity from 12,000 rpm rotational velocity to a shallow surface attack at 1000 rpm and to slight surface etching under static conditions.

In the latter two tests the disks gained in weight, probably as the result of the formation of adherent corrosion products. The results obtained at 1000 rpm are of interest because the corresponding peripheral velocity is approximately the same as the maximum linear velocity of coolant flow in the tubes of a

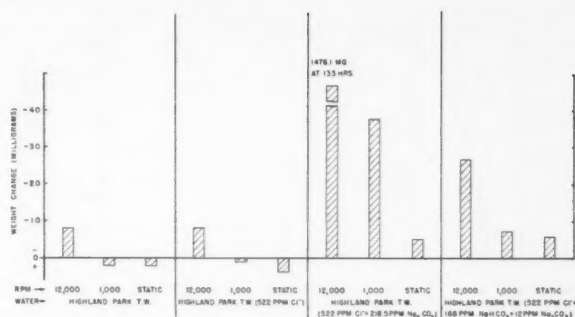


Figure 7—Effect of added chloride, carbonate and bicarbonate ions on corrosion of No. 100 brazing sheet in Highland Park tap water (200-hour test).

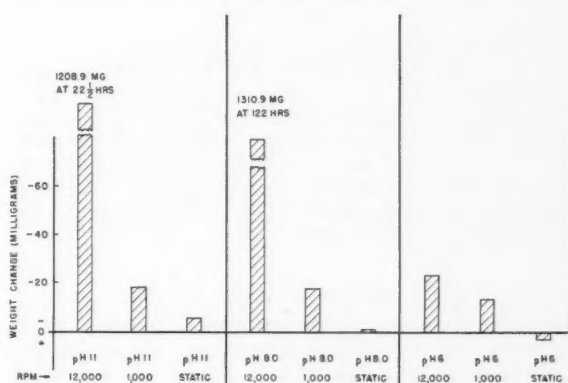


Figure 8—Effect of pH on corrosion of No. 100 brazing sheet in Royal Oak tap water with added chloride (to 522 ppm) in a 200-hour test.

Plymouth automobile radiator at 3300 rpm engine speed. At 1000 rpm in the corrosion test, the velocity of movement is 262 feet/minute average and 392 feet/minute maximum. In the Plymouth radiator, the maximum flow velocity in the tubes is 257 feet/minute at 2200 rpm and 385 feet/minute at 3300 rpm engine speed.

The second natural water, Royal Oak, Michigan tap water, was extremely corrosive, rapidly attacking the clad aluminum disk at 12,000 rpm (Figures 5 and 6). This attack began as localized pitting near the outer edge of the disk (similar in appearance to disk D in Figure 3). It rapidly developed into an erosion type failure as the pitting progressed laterally, eating away the cladding, and finally penetrating into the 3003 alloy core. The disk as photographed (disk A, Figure 3) was allowed to spin long past the normal failure point of 200 mg, which occurred at 60 hours. The appearance is shown after a weight loss of over 1600 mg in 93 hours.

Other investigators also have found that Royal Oak tap water is corrosive to aluminum.² To determine the reason for the large difference in action of Royal Oak and Highland Park waters, the analyses of the two were compared (Table 1). It is apparent that the more corrosive Royal Oak water is higher in chloride ion and alkalinity.

To test the effect of these components, artificial conditions were created in tap water with the fol-

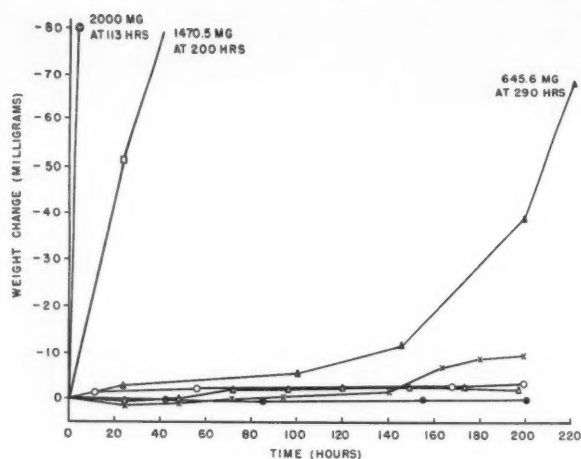


Figure 9 — Corrosion of No. 100 brazing sheet in various antifreeze mixtures at 12,000 rpm. ○ — Royal Oak tap water and ethylene glycol (1:1), □ — Highland Park tap water (522 ppm Cl) and ethylene glycol (1:1), ▲ — Royal Oak tap water (522 ppm Cl, pH 11) and ethylene glycol (1:1), × — Highland Park tap water (522 ppm Cl) and isopropyl alcohol (1:1), ○ — Highland Park tap water and methyl alcohol (2:1), △ — Royal Oak tap water and isopropyl alcohol (1:1), ● — Highland Park tap water, isopropyl alcohol and methyl alcohol (5:3:2).

lowing results. Addition of high chloride⁽¹⁾ only to Highland Park tap water appeared to cause a more general attack at 12,000 rpm than had occurred without the high chloride. The amount of corrosion measured by weight loss remained, however, approximately the same (Figure 7). On further testing to 500 hours, this situation had changed and the water with the high chloride concentration had caused a much greater weight loss (110 mg as compared with 30 mg). At both 1000 rpm and at static in Highland Park tap water, addition of the high chloride ion concentration appeared to have little effect on either amount or type of corrosion. Addition of high chloride ion concentration to Royal Oak tap water made no appreciable difference in the corrosivity of this water at 12,000 rpm (Figure 6).

Addition of high alkalinity⁽²⁾ only to Highland Park tap water greatly accelerated the attack at 12,000 rpm with resulting erosion and perforation (Figure 6). Addition of both high chloride and high alkalinity (as sodium carbonate) to Highland Park tap water at 12,000 rpm accelerated the corrosion greatly, the amount and type now being of the same order as found in Royal Oak tap water with high chloride ion concentration (Figure 6). Furthermore, the presence of both components accelerated corrosion at all three velocities (Figure 7). Presence of both components, but with the alkalinity added as sodium bicarbonate⁽³⁾ showed increased corrosion over the results in Highland Park tap water with high chloride alone at all speeds. The attack was not

nearly as serious, however, at high velocities as when the equivalent amount of carbonate alkalinity was present.

Effect of pH

A survey of the composition and properties of natural waters occurring in various parts of the United States showed that these waters all had pH values in the range of 5.9 to 10.4. For this reason, test waters were made up with pH 6 as the lower limit and pH 11 as the upper limit. This extreme alkalinity, of course, represented the most severe test condition that might be encountered in service. The pH of Royal Oak tap water with high chloride ion concentration, normally 8.0, was raised to 11.0 with sodium hydroxide, and lowered to 6.0 with hydrochloric acid. The attack on clad aluminum at 12,000 rpm in these three solutions, both visually and by weight loss measurements, shows a decided increase with increase in pH (Figure 8). At 1000 rpm and at static, weight losses increased very slightly with increase in pH; however, at the lower pH, the attack appeared to be more localized with resulting pitting.

From the preceding results, it is apparent that the solutions based on or approximating Royal Oak tap water were the most corrosive on No. 100 aluminum brazing sheet at 12,000 rpm. In fact, attack by this natural water was exceeded only when high chloride ion concentration was added to Royal Oak tap water and the pH raised with sodium hydroxide to 11.0. For reasons of availability and because the acceleration of corrosion appeared sufficient, Royal Oak tap water was selected as the test solution for the accelerated screening of inhibitors.

Corrosion by Antifreeze Solutions

Any inhibitors selected by this method also must be effective in and compatible with the common radiator antifreezes. For this reason the corrosion characteristics of the clad aluminum were studied in water-ethylene glycol solutions and water-alcohol solutions, representing permanent and non-permanent type antifreezes, respectively.

Water-ethylene glycol solutions (1:1) attack clad aluminum very rapidly at 12,000 rpm, as shown in Figure 9. This attack occurred using either a corrosive water (i.e., Royal Oak tap water) or a less corrosive water (i.e., Highland Park tap water with 522 ppm chloride ion). A drop in pH accompanied the attack, indicating formation of acidic products, undoubtedly due to oxidation of the ethylene glycol. In (1:1) Royal Oak tap water (522 ppm chloride ion and pH adjusted to 11.0) plus ethylene glycol, this attack was preceded by an induction period of about 150 hours. This induction period may have come about because of the time required to neutralize the high alkalinity (pH) provided by the water. In all tests, as shown in disk H of Figure 3, the attack was in the form of general corrosion over the entire surface.

Isopropyl alcohol, on the other hand, appeared to act as an inhibitor in (1:1) alcohol-water solutions.

⁽¹⁾ 522 ppm chloride ion total, a representative high chloride content for the natural waters of the United States.

⁽²⁾ 218.5 ppm sodium carbonate—this addition boosts the Highland Park tap water to the same total alkalinity found in Royal Oak tap water. Alkalinity is defined here as theoretical concentration of carbonate ion.

⁽³⁾ 168 ppm sodium bicarbonate + 12 ppm sodium carbonate—giving same total alkalinity as with the addition of sodium carbonate alone.

Very little corrosion occurred in these solutions regardless of the type of water (Figure 9 and Figure 3, disk J). Methyl alcohol and a combination of methyl and isopropyl alcohols acted similarly.

Effect of Velocity in Antifreeze Solutions

Weight loss of the clad aluminum in Royal Oak tap water—ethylene glycol solutions (1:1) remained low up to a velocity of rotation of 8500 rpm (see Figure 10). Increasing velocities above 8500 rpm appeared to reduce the induction period but the rate of corrosion appeared to be almost constant regardless of velocity.

It is not unlikely that even for the low velocities there occurs an induction period preceding a rapid increase in corrosion. The length of this induction period appears to be inversely proportional to the velocity of rotation, or rather to the amount of turbulence and resulting aeration of the solution, determining the rate of formation of acidic products from ethylene glycol. The induction period at 12,000 rpm was longer in this study of the effect of velocity than that found in an earlier run under similar conditions (Figure 9). This was attributed to the length of storage and purity of the ethylene glycol—a fresh supply having been obtained for the later runs.

The initial corrosion at the higher velocities was very similar in appearance to that occurring under static conditions. The few scattered pits, however, rapidly increased in number until the entire surface of the disks was attacked after a short time. Corrosive attack then remained general over the entire surface for the duration of the run.

In Royal Oak tap water—isopropyl alcohol solutions (1:1), velocity had no apparent effect. In such solutions the corrosion remained low at all velocities (Figure 11).

Summary

A technique of corrosion testing, accelerated by high velocity rotation of the test specimen, was investigated in connection with a program for selecting corrosion inhibitors for use in aluminum radiators. The effect of increase in velocity of rotation in Royal Oak tap water was to accelerate the attack of No. 100 aluminum brazing sheet, particularly at the high velocities—10,000 to 12,000 rpm. In Royal Oak tap water—ethylene glycol solutions, the effect of increase in velocity appeared to be to reduce an induction period that occurs before rapid corrosive attack sets in. In Royal Oak tap water—isopropyl alcohol solutions, velocity had no effect and corrosion remained low at all velocities. In general, the type of corrosion occurring initially at the high velocities was very similar to that occurring at low velocities and at rest.

The aqueous solutions particularly corrosive to the clad aluminum were those combining high chloride ion concentration and high alkalinity (except as sodium bicarbonate). High chloride alone caused no appreciable change in corrosivity on addition to tap water (200 hour run). On extended testing (500 hour run) at 12,000 rpm, attack was increased by this addition.

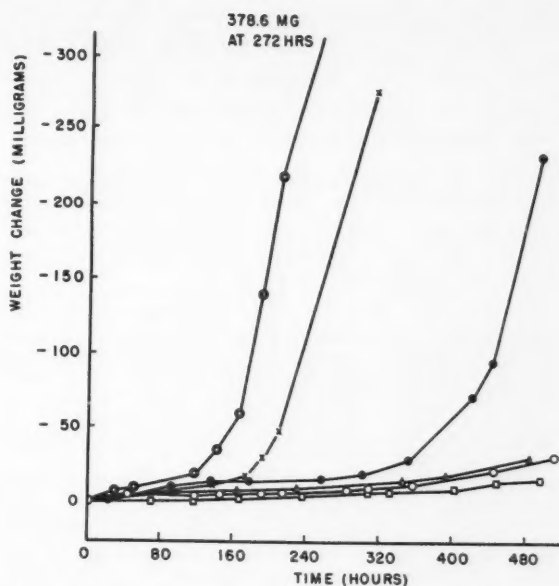


Figure 10 — Effect of velocity on the corrosion of No. 100 brazing sheet in 1 — 1 Royal Oak tap water and ethylene glycol. ● — 12,000 rpm, X — 10,000 rpm, ● — 8,500 rpm, Δ — 7,500 rpm, ○ — 5,000 rpm, □ — Static.

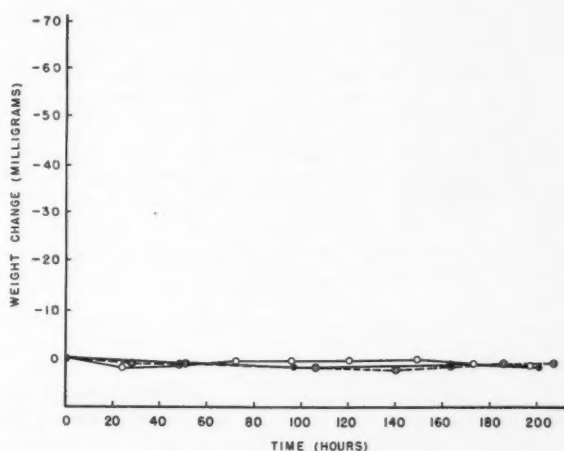


Figure 11 — Effect of velocity on the corrosion of No. 100 brazing sheet in 1 — 1 Royal Oak tap water and isopropyl alcohol. ● — 12,000 rpm, ● — 5,000 rpm, ○ — 1,000 rpm.

The solution selected for use in an accelerated test for screening inhibitors was Royal Oak tap water. The results of these screening tests will be presented in Part 2 in the following issue of *Corrosion*.

References

1. D. W. Sawyer and R. H. Brown. *Corrosion*, **3**, No. 9, 443-57 (1947).
2. Aluminum Company of America, private communication.
3. F. Wormwell. *J. Iron Steel Inst.*, **154**, No. 11, 219-28 (1946).
4. F. L. LaQue and W. C. Stewart. *Metals and Corrosion*, **274**, 147-64 (1948).
5. F. Wormwell, T. J. Nurse and H. C. K. Ison. *J. Iron Steel Inst.*, **160**, No. 3, 247-60 (1948).
6. R. May and R. W. de Vere Stackpoole. *J. Inst. Metals*, **77**, 331-44 (1950).
7. F. L. LaQue. Corrosion Testing, Edgar Marburg Lecture, 1951, Am. Soc. Testing Materials (1951).

8. A. A. Morton, B. Darling and J. Davidson, *Ind. Eng. Chem., Anal. Ed.*, **14**, No. 9, 734-6 (1942).

Discussion

Question by E. Wayne Everhart, Kaiser Aluminum and Chemical Corporation, Spokane, Washington:

The day is rapidly approaching when the automotive industry will be using aluminum radiators in large numbers. Therefore, your work is of considerable interest and value to many persons both in and out of the aluminum industry.

Because only the Al-Zn liner will be in contact with the coolant in an automotive radiator, would you distinguish between the corrosion behavior of the Al-Zn and Al-Si surfaces.

Reply by Sumner B. Twiss and Jack D. Guttenplan:

Some Al-Si cladding will be exposed to coolant at tube seams, so it seemed not illogical to expose both surfaces in the high speed test. The Al-Zn cladding constituted the top surface of the cylindrical test specimen and received the greatest attack from water impingement and turbulence. No experiments were run in the high velocity test with the Al-Si surface masked off or with the two surfaces reversed. For that reason we do not know whether we can distinguish between the corrosion behavior of the two surfaces in this test.

Preliminary electrochemical experiments involving corrosion current and potential measurements were made in pH 11 high chloride water with Al-Si and Al-Zn surfaces exposed alone, and with both surfaces exposed simultaneously. There was no significant difference in current or potential in the three cases. Lowering the pH from 11 to 7.5 by addition of buffer decreased the corrosion current the same amount in all three cases. Addition of a silicate in-

hibitor to the buffered solution resulted in a further decrease in current in the cases where the Al-Zn surface was exposed, but had no effect when the Al-Zn cladding was masked off. A large amount of white corrosion product was apparent on the Al-Si surface when the Al-Zn surface was masked off.

Discussion by John C. D. Oosterhout, The Texas Company, Port Arthur, Texas:

In regard to your comment about the corrosiveness of permanent antifreeze I would like to point out that present day permanent antifreezes are satisfactorily inhibited and less corrosive than the ordinary waters used in the radiators.

Reply by Sumner B. Twiss and Jack D. Guttenplan:

Of course in a study such as this the permanent antifreezes used did not contain the usual oxidation and corrosion inhibitors. It should be pointed out, however, that even though the commercial antifreezes based on ethylene glycol are satisfactory for brass radiators, there is no assurance that the same type of inhibitors will be satisfactory for use with aluminum radiators. In fact, it has been found that certain of the corrosion and/or oxidation inhibitors used with present antifreezes are promoters of aluminum corrosion. Any inhibitor-coolant system which is found to be satisfactory for use with Alclad aluminum must also be checked with all the other metals which it will come in contact in an automobile. Because of the possible differences in laboratory and performance tests, any inhibitor-coolant system must also be checked in full scale fleet tests in automobiles.

End of Part 1

Part 2 will be published in the July, 1956 issue.

Any discussions of this article not published above will appear in the December, 1956 issue.

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Iron in Oil Technique as a Corrosion Control Criterion*

By R. G. RYDELL and W. H. RODEWALD

Introduction

EVALUATION OF the corrosion protection afforded by inhibitors in producing oil wells is one of the most important endeavors of the oil company production men or department charged with corrosion control. To aid in the evaluation, both long-term and short-term methods of evaluating corrosion control are commonly used.

Long-Term Evaluation

Maintenance Cost

Long-term maintenance costs often are used to check other methods of corrosion control evaluation. With some wells no other suitable methods are available, and it therefore is the only method which can be used. Long-term maintenance costs provide an accurate review of results obtained although they are more of a historical summary type of control method.

In pumping wells one modification of this method has been the determination of the average number of sucker rod breaks during a specified length of time. With proper and good well corrosion data, this method gives a good picture of the dollars spent before and after corrosion control. It also provides the cost data which the corrosion engineer supplies to management as proof of an effective inhibition program.

This method, while excellent for evaluation of the overall program, many times requires a considerable length of time in order to determine the degree of protection obtained from the corrosion inhibition program in effect. In other words, the corrosion control being achieved at any given time may not be reflected in the corrosion maintenance costs for several months. In some areas of Kansas for example the field tests of corrosion inhibitors require a minimum of 1 to 1½ years for the corrosion engineer to determine, with any degree of accuracy, how good the inhibitor is and, therefore, how good the corrosion control has been.

Visual Inspection

Visual inspection is, of course, an excellent method of determining exactly how much corrosion has taken place over a period of time. The time necessary and cost involved limits inspection periods. Where the interior of the tubing is to be examined the tubing must be cut along its length or special instruments must be used on the tubing to allow the operator to "see" the effects of corrosion.

Caliper Surveys

Caliper surveys record the deviations from normal

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W. H. RODEWALD is assigned to the Oil Industry Chemical Department of National Aluminate Corporation, Chicago, Illinois. After serving in the U. S. Air Force he attended Purdue University where he obtained a BS in chemical engineering. Following his graduation from that institution he joined the Industrial Marketing staff of the Cities Service Oil Company where he became interested in corrosion problems involving overseas packaging and long term storage of manufactured materials. Mr. Rodewald is a member of ASLE, ASTE and NACE.



Abstract

A discussion of existing corrosion criteria is made. The need is pointed out for short term control to supplement present long term studies, especially where existing short term methods are questionable or not applicable.

Iron was found in the oil phase of produced fluids and was found present in particle form. Average values of from 25 - 150 ppm were determined with extremes varying from trace amounts to 2500 ppm.

Development of a technique to determine the amount of iron in the oil to simplify determinations was made. Trial methods which led to final Walker-Robertson technique are outlined and the technique is described in detailed form.

Evaluation studies were made on 94 sour wells which were using various corrosion inhibitors. Utilizing the iron in oil technique, correlation studies showed that a break point value of 55 ppm existed between economically corrosive and non-corrosive wells. Further studies in the Kansas area substantiated the findings with regard to the 55 ppm break-point. The dividing line between wells which are corrosive and those under good corrosion control may vary depending on the area. It is suggested that further work be done with this criteria of corrosion control to determine if applicable to various types of wells in various areas.

tubing wall thickness with tubing in place. A special probe is made to travel through the tubing, and metal feelers on the probe are deflected when a reduction in wall thickness is encountered. These deflections are recorded and compared to previous caliper recordings to evaluate corrosion control achieved. With proper inter-

pretation this method provides an accurate picture of the condition of the tubing at any specified time. This method is commonly used to substantiate other short-term corrosion control criteria and because of economic considerations is used to determine long-term corrosion control results.

Short-Term Evaluation

Coupon Evaluation

Coupon evaluation makes use of coupons (polished and weighed test strips) which are normally placed in the flow line near the well head. After exposure for periods of two weeks to one month or longer they are removed and weighed and weight losses recorded. Coupons are also placed in a special holder so that they can be installed at any desired depth in the tubing of flowing oil or gas wells. However, this is a more laborious and costly procedure than installing the coupon in the flow line at the well head.

Corrosion engineers and production men in general have found that in some instances, with sufficient background experience, coupons located at the well head will give an evaluation of corrosion control achieved. In other instances, however, this method has not proven satisfactory. Corrosion may occur in zones (various depths) in the well and a coupon located at the well head is not subjected to the same conditions as the metal at various depths. Placement of corrosion coupons in known corrosive zones in a well, rather than at the well head, corresponds to a more realistic approach to coupon evaluation. This method dictates the use of more time and money than if the test strips or coupons are placed in the flow line at the well surface.

Iron Content of Produced Water

There are certain types of wells which lend themselves to this method of evaluation. Good success has been achieved with this method of evaluation in gas and condensate wells. In this type of well, iron in water tests are valuable in determining the corrosion control achieved by chemical inhibitors. Where iron in water can be used, this method is suggested because of the simplicity of the analysis.

Persons interested in corrosion inhibition evaluation have felt the need for some time for a comparatively easy, short-term control method for producing wells to supplement existing long-term studies. A method which would serve where other methods had not been satisfactory or were questionable was particularly needed. Problems of this kind have been encountered, for example, with many sour wells. The prerequisites for a test such as the one mentioned above would be to quickly, easily and economically provide field information regarding the degree of protection being received at any given

time. It follows that the ability to quickly determine the effectiveness of a corrosion control program makes possible a greater degree of control resulting in dollar savings.

Method of Evaluation

Past experience has shown in most instances that the iron content of producing well waters is erratic. While many tests have been made on waters from sour wells, it was found in the majority of cases that these iron readings did not correlate with corrosion control information obtained by long term methods. In addition it was found that most iron in water readings were very low with many being below 1 ppm even in highly corrosive wells.

Inasmuch as many of the above wells were undergoing severe corrosion, it followed that the by-products of corrosion had to be present in some phase of the produced fluids. This would be the oil phase (i.e., the combined oil and interface). Work was started which was of such a nature that it would either verify or disprove this reasoning.

Approximately 50 oil fluid samples from various producing areas were subjected to existing wet ash analysis methods of determining the amount of iron in these oils. Tests showed the amount of iron occurring varied from trace amounts to 2500 ppm. Very few of these oils contained less than 10 ppm of iron with many iron readings in the 25 - 150 ppm range. This iron was thought to exist in two forms: (1) as soluble organic complexes which did not result from corrosion and, (2) as oxides, hydrates, and sulfides in a suspended form which were a direct result of corrosion.

Wet ash techniques are not suitable for use in the field, or where large numbers of samples are to be processed in the laboratory. In order to simplify the iron determination, straight acid-water extractions were made with dilute HCl in an effort to solubilize the iron salts and bring them into the water phase, thus making it possible to use a standard colorimetric method for determining iron in water.

Comparisons of this method with wet ash values showed that only a portion of the iron was extracted. Repeated extractions were made on the same samples of oil with periodic agitation to determine whether longer contact eventually would leach out the remaining iron products. The data in Table 1 illustrate typical results obtained. The iron content of the oil as determined by this method approached the iron content determined by wet ash methods only after unreasonable contact periods.

Heating the acid-water-oil mixture did not materially improve extraction until the wet ash method was approached. The method therefore did not lend itself to practical laboratory or field application, particularly where a large number of samples probably would be run.

Partition of Iron

If the iron salts were present in a finely divided form suspended in the oil as theorized previously, the acid might not have sufficient physical contact with the iron particles so that they could be dissolved and brought into the water phase. In order to determine whether the iron salts were actually present in particle form special methods as shown in Table 2 were employed to separate

TABLE 1—Results Obtained by Wet Ash Determination and Acid Extraction

Wet Ash Determination Fe (ppm)	Acid Extraction Values	
	Fe (ppm)	Time
311	73	1st day
	100	2nd day
	130	3rd day
	250	1 Week

these particles from the oil. Figure 1 illustrates the partition of iron in the total sample from which the oil in Table 2 was extracted. The relative values shown are fairly typical.

This study provided data which proved that the bulk of the iron salts are in the oil phase in particle form which can be removed by various methods. It was discovered during the course of the work that larger particles of iron products would plug sampling pipettes and some of the corrosion products would adhere to the inside glass surface of the pipette. This would occasionally give rise to erratic results. Therefore, the method of withdrawing an aliquot for testing purposes was changed. The following typical results in Table 3 compare wet ash with filtration methods where a graduate was employed for sampling. Because of the ease of using a graduate and the ease of transferring of the oil sample containing the iron products, the graduate was adopted for use in measuring aliquots in all future work.

Inasmuch as the filtration through submicron glass filter paper method gave iron readings comparable to the wet ash technique and because it represented a considerable saving in time, it was employed during the early stages of correlation studies.

During this period, further work was being done to simplify the method to make it more adaptable for large scale and rapid use. It was felt that if other means could be devised to obtain good physical contact of iron products with acid (with subsequent elimination of filter), the method would be more desirable. It was decided that advantage should be taken of solvent extraction methods in an effort to get the desired contact between acid and the iron salts.

Addition of Solvent

After addition of acid, a solvent such as carbon tetrachloride was added to the oil to lower its viscosity and raise its density. With this increased density the Fe-Oil- CCl_4 mixture formed a new layer below the acid layer. Violent boiling with evaporation of the solvent caused an inversion of the two phases. Prior to the return of the oil to the upper layer, a partial emulsification of the phases appeared to take place for a moment. Actually, the oil existed during this period in small droplets dispersed throughout the acid phase. Intimate contact of the acid and iron particles was thereby obtained. This process is rather likened to solvent extraction methods used in petroleum refining. Standard colorimetric methods are then used to determine the iron content as extracted into the acid-water layer. This is the essence of the extraction technique developed by Dr. A. O. Walker and R. S. Robertson at the National Aluminate Corporation Analytical Laboratory. Figure 2 illustrates the inversion of the layers and extraction of the iron into the acid-water phase.

Any iron tied up in organic complexes is not necessarily extracted by this procedure. However, unless the iron salts originate from corrosion, it is of no interest here. It might be questioned as to the effect of corrosion inhibitors in the extraction procedure or in the subsequent colorimetric determinations. Several inhibitors in wide use have been tested in these respects and were found to offer no interference.

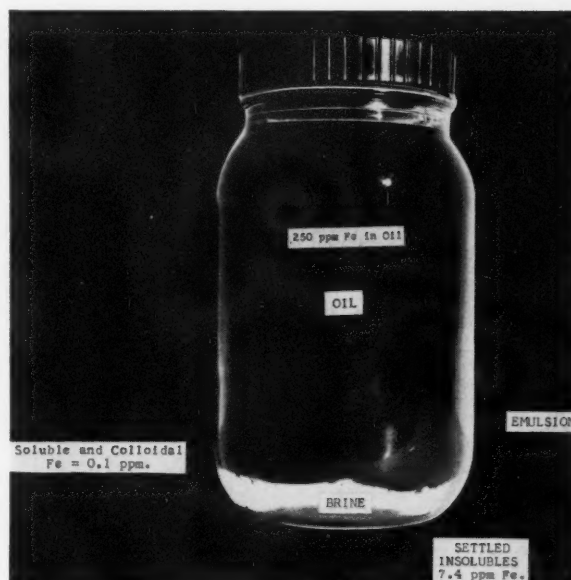


Figure 1—Partition of iron in typical sour oil sample.

TABLE 2—Results With Various Test Methods

Method	Fe ppm (Colorimetric)	Remarks
Wet Ash	210	Sampling would affect value obtained.
Filtered through a fritted glass micro filter. Washing with CCl_4 .	291	Filtrate wet ashed gave 37 ppm Fe. Corrected value 328 ppm. Filtration took 4 days.
Filtration through submicron glass filter paper, washing with CCl_4 . Used wet ash technique on paper to dissolve iron.	283	A blank of 10 ppm was subtracted for Fe found in paper used.
Centrifuged after diluting 1:10 with CCl_4 .	181	Result is sum of 146 ppm on solids at apex of tube and 35 ppm obtained by filtering supernatant fluid through Whatman No. 42 paper.

TABLE 3—Results Obtained by Wet Ash Method as Compared With Filtration Method

Sample No.	Wet Ash Method Fe (ppm)	Submicron Glass Filter Paper (Corrected for Blank) Fe (ppm)
1.....	117	125
2.....	71	82

TABLE 4—Comparison of Iron in Oil Results Obtained by Two Methods

Analysis No.	Wet Ash Method Fe (ppm)	Walker-Robertson Method Fe (ppm)
Well 1.....	37	35
Well 2.....	8	17
Well 3.....	92	85
Well 4.....	46	41
Well 5.....	9	10
Well 6.....	5	8
Well 7.....	96	92

The wet ash technique would be expected to give iron values higher than the extraction techniques because it supposedly includes all the iron either as corrosion products or those combined organically. However, the wet ash values were generally lower than the Walker-

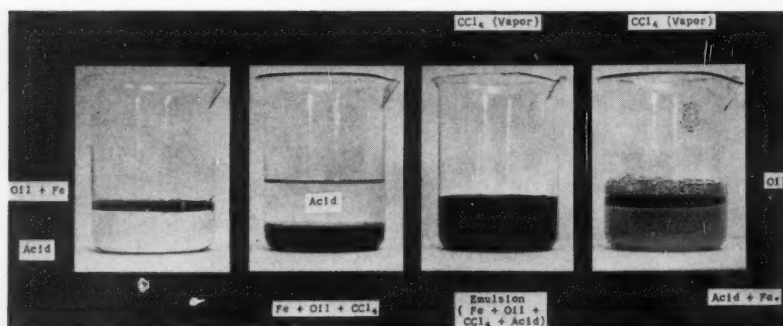


Figure 2—Four principal steps in the Walker-Robertson technique.

TABLE 5—Effect of Successive Extractions on One Sample Using Walker-Robertson Technique

	1st Extraction	2nd Extraction	3rd Extraction	4th Extraction
Aliquot 1.....	125	300	381	385
Aliquot 2.....	201	261	317	350
Aliquot 3.....	186	256	330	360

Robertson values. These unexpected results may be attributed to the volatilization or entrainment of iron in the wet ash procedure. Comparisons with standard wet ash determinations indicate that the accuracy is acceptable considering the accuracy of sampling well fluids. Table 4 illustrates typical results from a number of sour wells located in various sections of the country.

From a large number of determinations it was indicated that the greatest source of error occurred during sampling. These sampling variations may occur at three places: Once when the sample is withdrawn from the well, once when phase separation is made, and again when an aliquot of oil is taken for testing.

Additional Extractions

It was found that where the iron content exceeded 100 ppm, more than one extraction was necessary. A general rule was formulated that when the first extraction exceeds 100 ppm the extractions should be continued until the increase in subsequent values is less than 20 percent. This is usually obtained in 3 or less extractions except where the iron content exceeds 1000 ppm. In such cases four or more extractions may be necessary.

In making repeated extractions all that is necessary is to add additional solvent to cause inversion of the layers and to repeat vigorous boiling. However, it will be developed later that when the iron content exceeds a certain value, the corrosive conditions are considered to need attention and the exact values become less important, especially in the higher ranges.

The data in Table 5 illustrate the effect of successive extractions on one sample containing a high iron content.

Phosphoric acid (10 percent) was found to be the best acid for extraction purposes. It afforded complete extraction with minimum interference from stubborn emulsions, turbidity, and color. When employing phosphoric acid, it is necessary in only a few instances to add an iron-free emulsion breaker to aid in alleviating emulsion difficulties. Sulfuric acid tended to give low

results as well as troublesome emulsions. Dilute HCl (5 percent) was almost as good as phosphoric acid.

Carbon tetrachloride was chosen for the Walker-Robertson method because of its availability. Other solvents, such as chloroform, may be just as satisfactory.

Walker-Robertson Technique Procedure

The detailed procedure of the Walker-Robertson technique is described below:

Apparatus

1. One 10-ml graduate.
2. One 50-ml graduate.
3. One 1-pint bottle, wide mouth, with screw cap.
4. One 500-ml pyrex beaker.
5. One glass stirring rod.
6. One 5-ml graduated pipette (or 2-ml volumetric pipette).
7. Source of heat — electric hot plate, etc.
8. Photoelectric instrument, matched cells.

Reagents

1. Ten percent phosphoric acid.
2. C.p. carbon tetrachloride.
3. Emulsion breaker (iron-free).

Sampling

Siphon off water layer and settled solids leaving the oil layer and emulsified layers in the sample container. The amount of oil in the sample container should preferably exceed 100-ml.

Procedure

1. Shake oil and emulsified layers together vigorously for at least two minutes. Then rapidly pour 10-ml into a clean 10-ml graduate.
2. Transfer this 10-ml portion of sample into a clean, wide mouth, pint bottle, rinsing sample from graduate with approximately 50-ml of c.p. carbon tetrachloride.
3. Add 100-ml of 10 percent phosphoric acid to pint bottle, mix gently and cap. Shake vigorously for one minute.
4. Pour entire contents from pint bottle into a 500-ml beaker rinsing with a small quantity of CCl_4 . Begin to heat on hot plate. Heating should be done in a hood or near an open window so that injurious fumes will be withdrawn. Heat supplied must be sufficient to bring about vigorous boiling.
5. When boiling becomes vigorous, begin stirring with glass rod. Continue until all the carbon tetrachloride has been evaporated and the oil layer has re-formed on top. If sample has emulsified, add one to two drops of de-emulsifying agent and stir until emulsion breaks.
6. When cool, pipette aliquot of acid extraction layer from below the oil layer and continue with any

accepted colorimetric test for iron accurate to at least 0.05 ppm Fe.

7. Multiply results obtained by proper factor to obtain ppm of iron in the oil layer.

Factor = (ppm in acid-extraction layer) (10)

8. If the concentration obtained in previous step is higher than 100 ppm, more extractions should be made. Add another 50-ml of c.p. carbon tetrachloride to the 500-ml beaker and repeat steps four to eight. Extractions should be continued until the increase in succeeding values is less than 20 percent. This usually is obtained in three extractions. Report the highest value obtained.

Field Evaluation

To determine whether the iron in oil technique was of value as a corrosion control criterion, correlation of this method with existing long term corrosion maintenance evaluation studies was necessary. Actual maintenance records had to be compared to collected iron in oil data in as many wells as possible if information of any significance was to result. A program of field research was set up in several major oil producing areas and the aid was enlisted of interested operators who could provide maintenance data on wells undergoing surveillance. A group of Kansas sour producing wells was selected as a part of this study because of the detailed corrosion cost records available. Cost records were available two years prior to and during the evaluation study.

For eighteen months the average monthly maintenance expense charged to corrosion was carefully tabulated. Questionable maintenance expenses that could have conceivably resulted from other sources were listed as such but charged against corrosion for the purpose of the study. During this period iron in oil determinations employing the Walker-Robertson technique were compared against the inhibitor response as determined by maintenance costs. In order to summarize the data collected, the iron readings obtained over this period of time were averaged. Based on cost data, the wells were rated as to good, fair, or poor response to the corrosion inhibitors used. Table 6 lists the results of this eighteen month

TABLE 6—Results of 18 Month Study

Well	Inhibitor Response	Average Iron in Oil (Walker-Robertson Method)	Remarks (55 ppm Breakpoint)
A	Good	43	Correlates
B	Good	203	No Correlation
C	Good	39	Correlates
D	Good	51	Correlates
E	Good	30	Correlates
F	Good	47	Correlates
G	Good	53	Correlates
H	Good	46	Correlates
I	Good	45	Correlates
J	Good	43	Correlates
K	Fair	105	Correlates
L	Fair	32	Correlates (most expense occurred during last six months—Average Fe reading 71 ppm.)
M	Fair	82	Correlates
N	Fair	59	No Correlation
O	Fair	28	(Maintenance costs bordered good response) Correlates
P	Poor	217	Correlates
Q	Poor	133	No Correlation
R	Poor	24	(tubing splits and collar leaks might have been mechanical) Correlates
S	Poor	132	Correlates

study and it was noted that an iron in oil value of 55 ppm seemed to represent the break-point between good and poor inhibition.

Using 55 ppm as the break-point it was found that correlation between iron in oil - maintenance cost data existed in roughly 84 percent of the wells observed.

To provide additional information 722 tests were made on 95 wells over a ten month period in the West Texas area. Ten interested operators using a variety of inhibitors entered into the program and provided maintenance data for comparison purposes. Their cooperation resulted in the data shown in Tables 7, 8, 9 and 10.

Referring to Table 7, all 36 wells experienced considerable corrosion as determined by the number of tubing, pump, and rod jobs reported. In order to make the study more valid, each group of wells operated by the participants was evaluated separately. A fairly representative example of the iron in oil values and maintenance records taken is shown in Table 8. It is interesting but not necessarily significant that the average iron readings as shown in Table 8 (6 wells) roughly corresponds to the average of all 36 wells.

Average monthly analyses on 59 of the 95 wells gave readings as shown in Table 10. None of the wells in this group experienced any significant corrosion failures during the 10 month period.

It can be noted from the above data that in these cases there was a fairly wide break-point between corrosive and non-corrosive wells. This particular set of data again pointed to the fact that an upper limit of 55 ppm was not exceeded in the non-corrosive wells.

Although the break-point between the economically corrosive and non-corrosive wells was found to be 55 ppm in the above examples it is likely that different break points will be noted in various areas. It is believed that considerable variation in optimum iron in water

TABLE 7—Monthly Average of Iron in Oil Determinations for 36 Wells in West Texas Area¹

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
294	244	660	127	110	240	104	337	160	219

¹ Total No. of Tests—309

TABLE 8—Average Iron in Oil Determinations for 6 Wells in West Texas Area

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
293	247	753	113	79	308	91	401	189	233

TABLE 9—Maintenance Record on Number of Repair Jobs Per Month

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
11	7	3	5	3	1	5	6	4	7

Note: 1 Unit—Rod or Pump Job; 2 Units—Tubing Job.

TABLE 10—Average Iron in Oil Determinations on 59 Successfully Inhibited or Non-Corrosive Wells¹

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
35	39	52	36	39	34	28	29	27	49

¹ Total No. of Tests—413.

readings also have been noted from one area to another where this method is used as a corrosion control criterion for distillate wells. There is reason to believe that the same situation may exist with the use of iron in oil evaluation studies.

Sampling

The best sampling technique would involve the following:

1. Thorough flushing of by-pass line at the well head.
2. Use of a large container (one gallon or larger) to sample produced fluids. This container should be flushed with produced fluids from particular well in question.
3. Draining of as much water from sample as possible by siphoning, inverting of bottle, etc. (may have to be repeated several times to obtain 100 ml of oil).
4. In step 3 above, care must be taken not to siphon off interfacial layer which may be iron rich.
5. Thoroughly agitate and pour this oil into a clean wide mouth pint container with plastic cap.
6. Iron reading can be run in field laboratory or central laboratory as desired.

If a tight emulsion of the produced fluids exists at the time of sampling, a small amount of iron-free emulsion breakers may be helpful to separate the water from the oil. Although not as desirable, the wide mouth one pint jars can be used to obtain samples at the well head. In a high water cut well this procedure may require a number of repeated fillings and inversions of the bottle to drain the water in order that sufficient oil can be obtained for testing purposes.

The number of samples taken during the iron in oil evaluation program is determined in a manner similar to the number taken when iron in water methods are used. That is, more samples are generally necessary during the beginning period with less samples required when an effective program has been established. As an example, the operator may wish to take one reading per week for a one month period prior to start of the inhibition program. After addition of the inhibitor to be considered, it is suggested that there be an elapsed period of approximately two or three weeks before additional tests

are made. Because of the detergency action of some inhibitors this period may be required in order that old iron deposits can be cleaned from the metal surfaces. It has been observed that iron in oil values after initial treatment with inhibitor have increased, probably as a result of this detergency action. Iron in oil readings can then be taken in sets of two, one day apart, every other week until the effect of treatment is established.

Depending on the iron in oil readings, the treatment can then be adjusted downward or upward and the subsequent effect noted. Experience shows that high readings may occasionally occur following well repair work because of the loosening of old corrosion products. Samples should be taken when it is felt the well is operating in a normal fashion.

High readings should be checked if a pattern of lower readings already has been established. One reading does not normally represent a trend unless previous or subsequent values indicate a change is in progress.

Conclusions

The Walker-Robertson method of determining the amount of iron in oil has proven to be a technique suitable for processing a relatively large number of samples with acceptable accuracy. To date, field data show this method to be a valuable corrosion control criterion for sour wells. Preliminary sweet well data are being collected and tabulated to determine the applicability of the iron in oil technique in this type of service.

In an effort to further establish the validity of this short term evaluation criterion additional work is needed and it is hoped that others interested in producing well corrosion problems will be able to further evaluate this control measure. Should further evaluation of this method substantiate its value, it would be of service to the industry in predicting corrosive conditions, evaluating corrosion control programs and indicating response of wells to particular inhibitors and for feeding methods.

Acknowledgment

The authors gratefully acknowledge the cooperation of the petroleum companies participating in this program. Further thanks are given to Dr. A. O. Walker and R. Robertson for their invaluable laboratory work and assistance in preparation of this paper.

Any discussions of this article not published above will appear in the December 1956 Issue.

A Radiochemical Tracer Investigation Of the Role of Mercury in the Corrosion of Aluminum*

By R. C. PLUMB, M. H. BROWN and J. E. LEWIS

Introduction

CORROSION OF aluminum equipment has been attributed in a number of instances to mercury contamination. Brown et al¹ have given examples of mercury contamination and the resulting corrosion having caused failure of equipment made from non-ferrous metals. In most such cases it is thought that the mercury originated from broken thermometers or mercury-bearing apparatus. It is often difficult to show that mercury contamination is the cause of corrosion, because in many cases where mercury is definitely indicated, only small amounts of mercury can be found on an aluminum surface by standard analytical techniques.

Edwards, Frary and Jeffries² thought the action of mercury prevented the adherence of the aluminum oxide to aluminum and hence promoted continuous oxidation.

Brown, Binger and Brown¹ demonstrated that mercury as vapor, as mercuric ion, and as mercurous ion may accelerate the corrosion of aluminum. They showed in a striking manner how easily mercury may go through a process system in the form of mercury vapor. They were not able to account by the usual analytical methods for all the mercury which had been placed in a system and were not able to measure the partition of mercury between the aluminum surface and the solution.

Quillard³ has shown that even small amounts of silicon and manganese as well as other elements increase markedly the resistance of aluminum to amalgamation.

Radioactive tracers provide a convenient analytical tool for measuring the partition of small amounts of radioactive material between different portions of a system. For this reason and because the distribution of radioisotopes on a surface may be determined by autoradiographic techniques, it seemed desirable to apply tracers to this study. The use of radioactive tracers in studies of surface reactions has been reviewed by Simnad.⁴ Aziz⁵ recently has employed radioactive tracers to study the distribution of local anodic-cathodic couples on aluminum surfaces.

Experimental

Radiochemical

Radioactive mercury was obtained by neutron irradiation of mercuric oxide in the Oak Ridge X-10 reactor, yielding two radioactive isotopes of mercury, mercury-197 and mercury-203. The latter material has a half-life of 51.5 days. The mercuric oxide was



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Abstract

A radioactive tracer investigation of the role of mercury in the corrosion of aluminum is described. Radioactive tracer techniques have permitted this study to be carried out more precisely than possible by standard analytical techniques, because they permitted accurate quantitative measurements of mercury pickup and revealed the distribution of mercury on exposed specimens. Particular attention has been given to the mechanism by which aluminum corrodes in a solution of mercuric salt. A process by which mercury makes the initial attack on aluminum, the manner in which further pickup takes place, and the relationship between the mercury pickup and the resulting corrosion have been deduced. Several results of practical consequence are described. Included is a technique for removing mercury contamination from aluminum.

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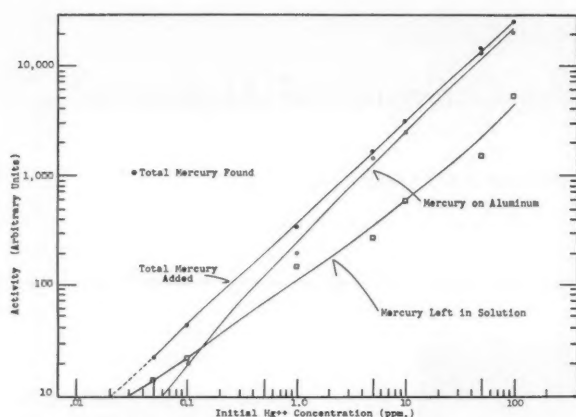


Figure 1—Pickup of mercury by four square cm of 3003 aluminum exposed to 100 ml of radioactive Hg^{++} in 0.5M NaCl for 7.1 days at an initial pH of 4.

dissolved in hydrochloric acid and evaporated to dryness. The mercuric chloride was sublimed onto the walls of the flask, scraped out, weighed and dissolved in distilled water. This material was kept as a stock supply for the preparations of solutions in which samples were to be placed.

Two alternative counting techniques were used. In some of the work, the beta rays were measured by an end-window Geiger tube. Because the beta radiation has very low penetrating power, a standard sample preparation technique for counting had to be adopted to avoid self-absorption errors. This procedure consisted of adding inactive carrier mercury to solutions and samples, dissolving the sample, and precipitating the mercury with hydrogen sulfide. The radioactive mercury content of these samples could then be determined by a direct comparison of the beta activity of the mercuric sulfide precipitates with the beta activity of a standard containing a known amount of radioactive mercuric sulfide.

Considerable simplification was achieved by measuring the gamma ray emission from the mercury with a NaI scintillation counter. With very penetrating gamma radiation, the problem of self-absorption was eliminated to a great extent. It was, however, necessary to keep the counting geometry constant in comparing samples. For liquid samples, standards were prepared by adding known amounts of mercury to an equal volume of solution.

Some difficulty was encountered in preparing standards for measuring the mercury on solid samples. A large part of the mercury was lost when an aliquot of a standard solution was evaporated on a solid sample.

A satisfactory procedure was to place the aliquot of radioactive mercury solution on the surface of the sample and count it without drying. This, of course, necessitated the preparation of a new solid standard each time it was necessary to make measurements on a specimen. By varying the volume of the liquid aliquot, keeping the amount of mercury the same, it was established that the activity of the standard was equal to that of the same amount of mercury on a corroded surface. All measurements were corrected

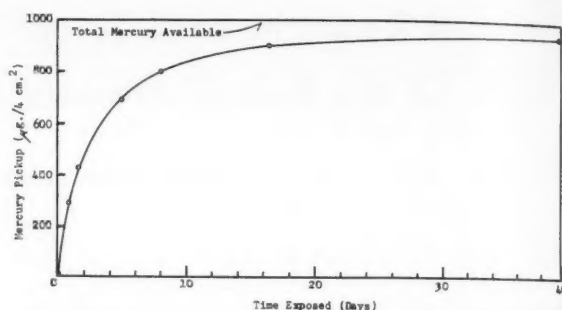


Figure 2—Pickup of mercury from 100 ml of 10 ppm radioactive Hg^{++} in 0.5M NaCl by four square cm of 3003 aluminum alloy as function of time at a pH of 4.

for decay of the mercury, and all measurements were made with sufficiently long counting times to assure a statistical precision of 2 percent.

The autoradiographic methods used to determine the distribution of mercury on specimens corroded in radioactive mercury solutions were similar to those described elsewhere.^{4, 5, 6}

Sample Preparation

All the specimens employed in this investigation were of wrought aluminum and were 1-inch square and 0.064-inch thick. Several different alloys were used. Except as noted in the sections to follow, the standard procedure for sample preparation was to degrease with petroleum ether and etch slightly (one minute) in a 2 percent HCl, 2 percent HNO_3 solution. The specimens were then rinsed in distilled water and dried.

For all quantitative work, the edges and back surface of specimens were taped with Scotch electrical tape to eliminate edge effects. A 4-square cm area of aluminum was left exposed. The Scotch electrical tape was found to adsorb no mercury except in one case where some of it was exposed to 70 percent nitric acid in contact with aluminum for 24 hours and was partially oxidized.

Material Balances

Material balances comparing the amount of mercury put into a system with that found at the end of a test were performed on several occasions. The amount of mercury added to a system and the amount found both in the solution and on the specimen over a concentration range of .05 ppm to 100 ppm are shown in Figure 1. The material balance was excellent and lends a great deal of support to the validity of results which were obtained.

Results and Discussion

The experimental work has been devoted to answering several general questions. The first division of the work concerns the kinetics of mercury pickup, the second division concerns the dependence of pickup of mercury upon the mercury concentration and the alloy, and the third division concerns the relationship between mercury pickup and corrosion. The fourth division is devoted to the details of how the attack of mercury on aluminum takes place.

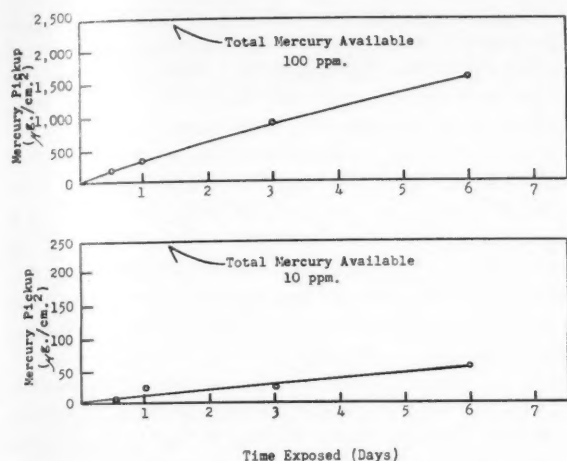


Figure 3—Mercury pickup from 100 ml of various concentrations of radioactive Hg^{++} in 0.5M NaCl at an initial pH of 6 by four square cm of 3003 aluminum alloy as a function of time.

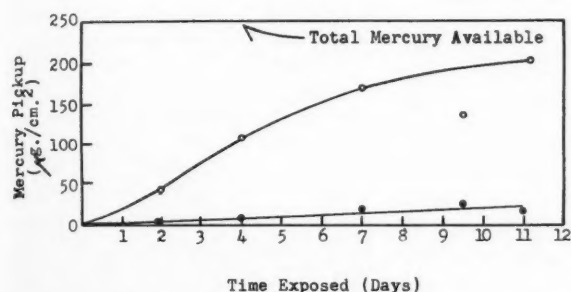


Figure 4—Pickup of mercury from 100 ml of 10 ppm radioactive Hg^{++} in 0.5M NaCl at an initial pH of 6 by four square cm of 3003 aluminum given two different surface treatments. The top curve is for HCl-HNO₃ etch, wash; bottom line is for Alcoa R-5 bright dip, boiled distilled water (1 hour).

The practical implications of this work to industrial applications of aluminum are given later in the paper together with the results of evaluations of methods of removing mercury from aluminum.

Kinetics of Pickup of Mercury from Solution

If one considers the pickup as resulting from electrochemical reduction, any one of several things may, under different conditions, be expected to act as the rate controlling step. These conditions include diffusion through the solution, diffusion through the corrosion products and penetration of the oxide.

The general shape of the pickup versus time curves may vary widely, depending on the conditions as shown in Figures 2, 3, 4 and 5. In Figure 2 at an initial pH of 4 an exponential pickup curve was observed. Similar curves were observed over a wide concentration range.

It was observed that agitation of the solutions greatly increased the pickup in short times. It is concluded that, for those experimental conditions and with the oxide coating which was on the specimens, the pickup was limited by the rate at which

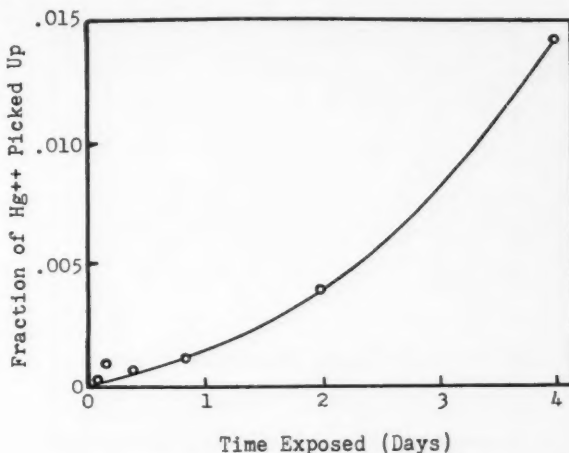


Figure 5—Pickup of mercury from 100 ml of 100 ppm radioactive Hg^{++} in distilled water by four square cm of 3003 aluminum alloy.

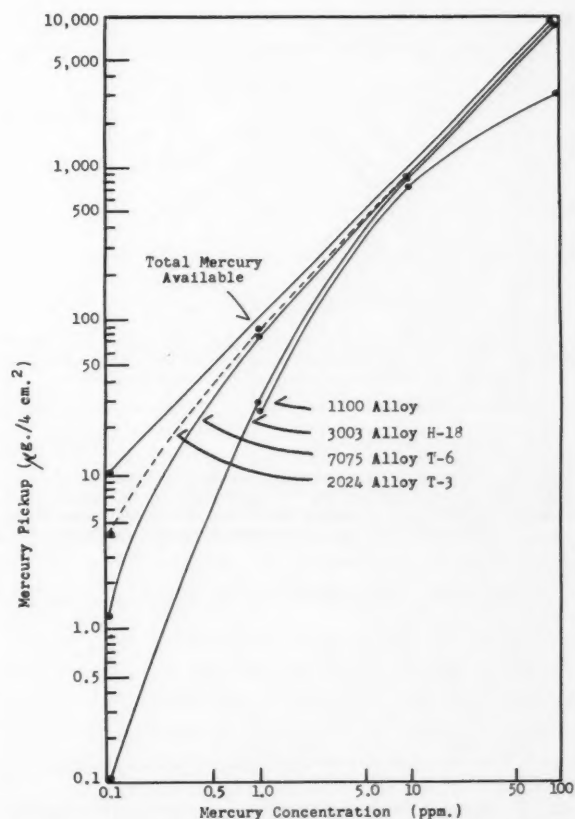


Figure 6—Pickup of mercury in 10 days by four square cm of several aluminum alloys exposed to various concentrations of radioactive Hg^{++} in 0.5M NaCl at an initial pH of 4.

mercuric ion diffused through the solution to the specimens. At an initial pH of 6 the pickup was much slower and the rate of pickup depended strongly on concentration as shown in Figure 3. Because the pickup is slower at a pH of 6 than at a pH of 4 the corrosion products which deposit at a pH of 6 may act as a barrier to pickup. Alternatively, because the

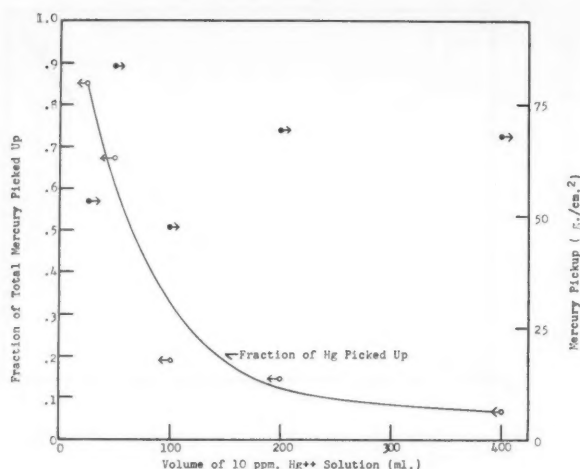


Figure 7—Pickup of mercury from various volumes of 10 ppm Hg^{++} in 0.5M NaCl by four square cm of 3003 alloy in four-day exposure at an initial pH of 4.

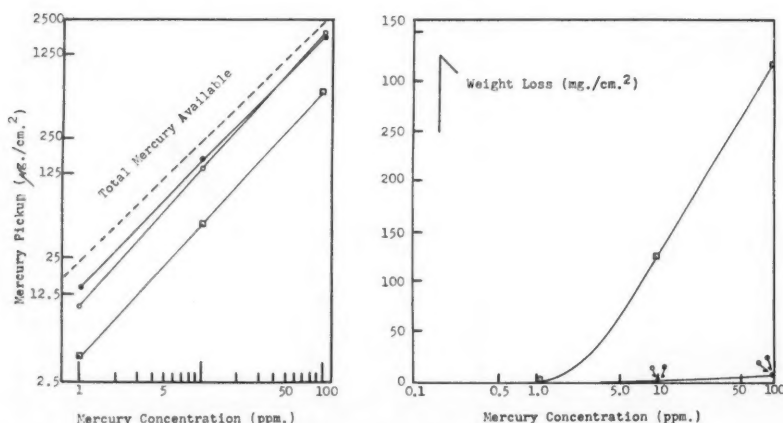


Figure 8—Pickup of mercury and weight loss for four square cm of various alloys exposed to various concentrations of radioactive Hg^{++} in 0.5M NaCl for 10 days at an initial pH of 4. Line drawn through shaded circles represents 3003 alloy H-18; line drawn through plain circles represents 6061 alloy T-6; line drawn through squares represents high purity (99.995).

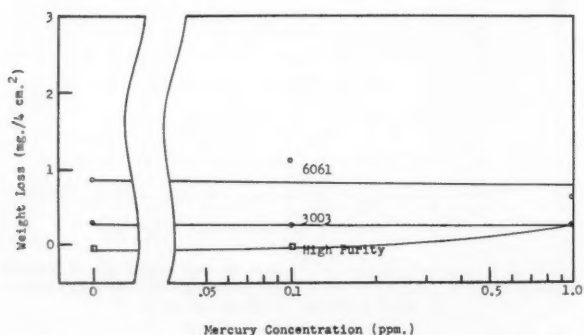


Figure 9—Weight losses of three alloys exposed to low concentrations of mercury in 100 ml of 0.5M NaCl at an initial pH of 4 for 14 days.

protective oxide coating on aluminum is attacked more rapidly at low pH's than at neutral pH's, the oxide barrier may have been broken down so rapidly at low pH's that the pickup was limited primarily by the diffusion rate.

Several experiments established a dependence of the rate of pickup on the surface treatment given a specimen before placing it in a mercury-containing solution. Figure 4 shows the results of one such study where it was found that a hydrated oxide film obtained by boiling a specimen cleaned by the Alcoa R-5 Bright Dip⁽¹⁾ in distilled water for one hour greatly increased resistance to pickup over that of a specimen given the standard surface cleaning. In another study, specimens cleaned with the Alcoa R-5 Bright Dip but without having been given a hydrated coating, corroded so rapidly that pickup measurements were not feasible.

In solutions of mercuric chloride in distilled water, the pickup was much slower than in sodium chloride solution. As shown in Figure 5, the pickup curve was auto-accelerating. It is thought that an increasing rate of pickup results from corrosion enlarging the initial oxide flaws where mercury deposits. The higher rate of pickup when sodium chloride is present may be attributed to the relatively rapid breakdown of the protective film.

A fourth effect enters into the considerations of the factors controlling the pickup of mercury by aluminum. It was frequently observed (for example, 1100 alloy, Figure 6) at high concentrations with certain alloys which are attacked most rapidly by mercury that the pickup was abnormally low. A reasonable explanation is that the mercury is carried away from the surface by the corrosion products in a manner analogous to that involved in the growth of oxide from an amalgamated surface in moist air where droplets of mercury may be seen in the oxide.

Dependence of Pickup Upon Concentration of Mercury and Alloy

To measure the dependence upon alloy and concentration, studies were carried out at pH of 4.0, which gave the results shown in Figures 5, 6 and 7. From Figure 5 it is seen that at high mercury concentrations the pickup is almost complete, while at low concentrations only a small fraction of the mercury is picked up.

The observed dependence of completeness of pickup on concentration is especially interesting because the reduction of mercuric ion to mercury by aluminum is energetically so feasible that one would expect it to be quantitative. One possible explanation is the difficulty of moving the aluminum ions through the surface films. The blocking of the reaction would cause less mercury to be reduced. However, as the concentration of mercury in the solution increases, more and more mercury will be reduced and as more

⁽¹⁾ U. S. Patent 2,650,157.

amalgam with the aluminum is formed the barrier to further reduction will be lessened because the oxide formed over an amalgam may break away readily.

Another explanation may be built around the fact that mercury is carried away from the surface with the corrosion products. It is doubtful, however, that it holds at high concentrations. It can be seen from Figure 8 that the weight loss may increase by a factor of a few thousand as the concentration increases from 1 ppm to 100 ppm, whereas the fraction of the mercury picked up remains about the same.

The results of two investigations to determine the relative tendency for several alloys to pick up mercury from solution over a wide concentration range are given in Figures 6 and 8. The most noticeable differences between alloys are at low concentrations (e.g., at 0.1 ppm) where differences up to a factor of 10 or more were observed.

At 1 ppm, high purity aluminum (99.995 percent) and 1100 aluminum alloy showed the least tendency to pick up mercury. The 6061-T6 alloy showed the next greatest tendency with 3003-H18 alloy slightly greater; 7075-T6 and 2024-T3 alloys showed the most tendency. The relative pickup may be explained if one assumes that the reduction of mercury takes place through small anodic-cathodic couples on the surface of the sheet. The reasoning there is that the pickup would increase with the increase in the number of couples in the more alloyed forms.

In order for the results shown in Figures 5, 6 and 8 to be of general value, it would be desirable to know the dependence of the observed pickups on the ratio of the volume of the solution to the area of the sample. One may expect that when only a moderate amount of the mercury is picked up, an increase in the volume of the solution would not increase the amount of mercury picked up, inasmuch as the surface is already saturated.

An experimental verification of the expected behavior is shown in Figure 7 where it is seen that 50-80 micrograms of mercury per square cm are picked up by areas of the same size exposed to 10 ppm mercury solutions differing in volume by a factor of 16. However, when a large fraction of the mercury is picked up, the surface may not be saturated and an increase in volume may result in more pickup.

Relationship Between Mercury Pickup and Corrosion

Several studies were carried out to determine the manner in which the pickup of mercury is related to corrosion. The results of the studies are shown in Figures 8, 9 and 10.

From Figure 9 it is seen that low concentrations of mercury do not greatly increase the corrosion of aluminum in .5M sodium chloride solution. Alloy 6061 gave the largest weight loss with no mercury present, but it did not show a measurable increase in weight loss at concentrations up to 1 ppm.

From Figure 8 it is seen that at concentrations above 1 ppm the corrosion of high purity aluminum increased greatly and the corrosion of 3003 and 6061

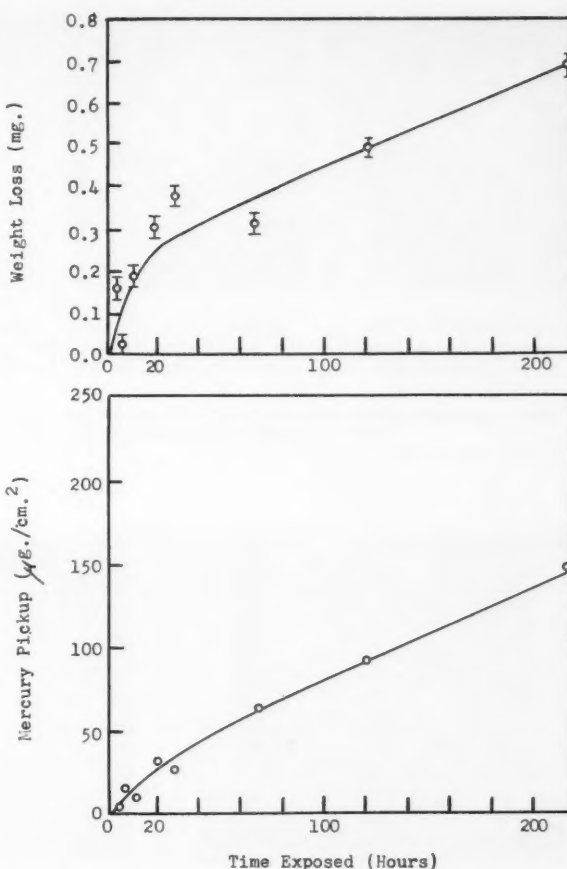


Figure 10—Pickup of mercury and weight loss for four square cm of 3003 aluminum alloy exposed to 10 ppm of radioactive Hg^{++} in 0.5M NaCl as a function of time at an initial pH of 6.

alloys increased, but to a lesser extent. It is immediately apparent that there is no simple relationship between pickup and corrosion under these conditions. This is known to be true because the mercury may be picked up at low concentrations without resulting in corrosion, while at high concentrations high purity aluminum, which picks up the least mercury, corrodes the most.

In Figure 10 the results of a study of weight loss and pickup as a function of time at a pH of 6.0 are given. Within the first 30 hours, about 40 percent of the total corrosion occurring in 220 hours takes place. It is apparent that in a solution at a pH of 6 the corrosion products provide a barrier to further corrosion just as they provide a barrier to further pickup. Thus, the pickup and corrosion in the first few hours are more rapid than after the corrosion products accumulate.

It is interesting to note, as shown in Figure 8, that aluminum alloys such as 6061 and 3003 pick up more mercury than high purity aluminum but do not corrode as much. It would be expected that more galvanic cells would be present in the alloyed materials, and these would increase the opportunities for deposition of mercury. The fact that the greater deposition of mercury on the alloyed materials did not in-

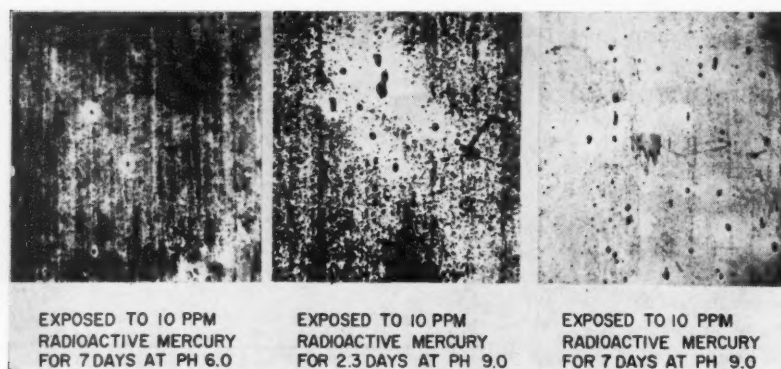


Figure 11—Autoradiograms showing distribution of mercury on a variety of corroded 3003 alloy specimens. Approximately 3X.

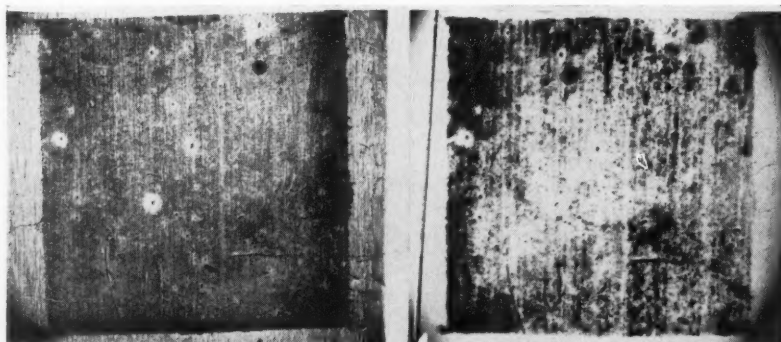


Figure 12—A 3003 aluminum specimen (left) exposed for seven days (at pH 6) to 10 ppm mercury in 0.5M NaCl. Autoradiogram at right shows distribution of mercury on surface. Approximately 3X.

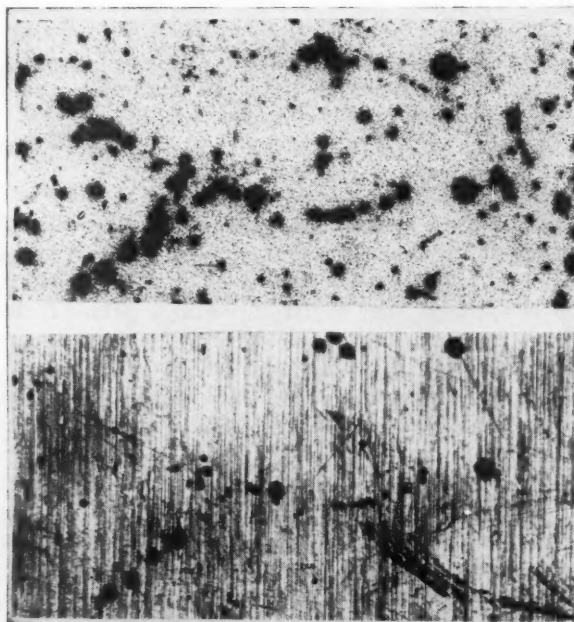


Figure 13—Autoradiogram (top) of mercury and corresponding portion of pitted aluminum surface (bottom) of 3003 aluminum sheet exposed to 1000 ppm mercury solution. 12X.

crease the corrosion as much as lesser deposition on high purity aluminum appears to be analogous to the effect of other elements noted by Quillard.

The Mechanism of Pitting

When aluminum was placed in progressively higher concentrations of mercury, it was found that the initial attack became more and more localized. The autoradiograms demonstrating this behavior have not been reproduced. Pickup from 0.1 ppm after 6.2 days was just barely discernible but appeared to be uniform. After 0.5 days, the pickup at 1 ppm showed some tendency to be localized, while at 10 ppm it was very localized. As corrosion progressed and the original surface broke down, the whole surface became amalgamated.

Figure 11 shows several autoradiograms obtained on specimens exposed to 10 ppm of mercury which exhibit a localized attack superimposed on a generally corroded surface. Some of the points where there were high concentrations of mercury were surrounded by annular zones where there had been no mercury pickup, while other points at high mercury concentrations were simply superimposed on the rather continuous background of general corrosion.

posed on the rather continuous background of general corrosion.

Figure 12 shows that only those points which were surrounded by annular regions of no pickup were associated with well developed corrosion pits. Apparently, at a point with a given high concentration of mercury, the point may or may not develop into a corrosion pit.

Figure 13 shows an autoradiogram and the corresponding portions of a metal specimen which had been exposed to 1000 ppm of radioactive mercury containing a small amount of hydrochloric acid. The specimen was exposed for a short time that was just sufficient to permit development of well defined pits. Figure 13 shows that for every corrosion pit developed there was a large concentration of mercury on the surface. It shows also that there were many points where there was an equally high concentration of mercury with no pitting.

An experiment was performed to determine the variation in pickup and corrosion with an applied voltage on a specimen. In Figure 14 autoradiograms made from specimens placed in 1000 ppm of mercury in .5M sodium chloride with +10 volts, 0 volts and -10 volts applied voltages are shown which reveal the distribution of mercury on the surfaces. It is seen that at +10 and -10 volts the mercury pickup is

greater than at 0 volts. These results indicate that mercury can be picked up in both anodic and cathodic areas.

A mechanism which is thought satisfactory for explaining these several observations as to the nature of pitting is illustrated schematically in Figure 15. It is thought that there is an initial development of anodic and cathodic regions resulting in electrochemical deposition of mercury at the cathodes. Depending upon the nature of the oxide film in an initially cathodic region, the mercury may amalgamate with the aluminum, thereby making the region anodic. Alternatively, the mercury may deposit and not amalgamate for a considerable period of time, or not at all.

In the areas where the mercury does not amalgamate, the bulk of the mercury may be on the outside of the oxide film but connected to the aluminum by a thin path of mercury, so the solution of mercury in aluminum may be extremely slow. As long as the mercury does not amalgamate, the deposit would remain cathodic and in this case mercury would act like any other heavy metal. This may explain the presence of mercury in some areas which did not corrode as shown in Figure 13. As was shown in Figure 14, mercury can also deposit in the corrosion pits and upon amalgamation intensify the corrosion at local points.

At low concentrations, as shown in Figure 11, another effect comes into being. There are certainly high concentrations of mercury at some points which have corroded more than others, but there is also the important fact that the points of high mercury concentration which do corrode badly are surrounded by annular regions of low mercury pickup. It seems doubtful that a reasonable explanation for the annular ring can be made in terms of these regions being electrochemically protected by the corrosion adjacent to them, inasmuch as it is demonstrated in Figure 14 that making a region more cathodic deposits more mercury. In view of the indications that corrosion products inhibit the pickup of mercury, it would seem more reasonable to say that the annular regions with no pickup and no corrosion result from the corrosion products precipitating around the pit and acting as a barrier against pickup of mercury in these regions.

An alternative explanation of the annular rings is that as corrosion proceeds in the pit more and more fresh aluminum is exposed and small galvanic couples are set up within the pits. Mercury is deposited so readily that the solution adjacent to the pit is depleted of mercury, and not enough is available to deposit in the annular rings. These annular zones which do not pick up mercury are apparently identical to the "passive zones" noted by Aziz.⁵

Some Practical Implications of Results to the Aluminum Industry

Among the more general results of practical interest are those concerning the maximum concentration of mercury required to accelerate the corrosion of aluminum, the differences between alloys in sus-



Figure 14—Autoradiograms showing variation of Hg pickup with applied voltage.

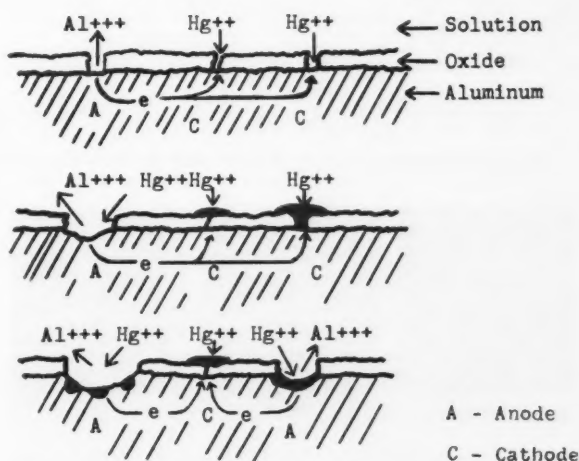


Figure 15—Schematic representation of pitting of aluminum in a mercury-contaminated solution. Top drawing represents step 1, middle drawing step 2 and bottom drawing step 3.

ceptibility to attack by mercury, and the feasibility of preventing mercury attack by coating treatments.

It may be expected that under the conditions of these tests, mercury concentrations below 0.1 ppm do not accelerate the corrosion of aluminum. It should be emphasized, of course, that in another corrosive media mercury might have an effect on corrosion at even lower concentrations.

A second result of practical significance is that the higher the purity of the aluminum the greater the tendency for it to corrode in mercury contaminated solutions.

Removal of Mercury from Aluminum

It was desired to evaluate several chemical procedures for removing mercury from aluminum. The results of tests with several cleaning agents are shown in Table 1. Distilled water has been included as a blank. Specimens were exposed to radioactive mercury and the pickup measured. Specimens were then given the cleaning treatments listed in the table, and the remaining mercury measured. It is seen that 5 percent chromic acid and 70 percent nitric acid were effective while other treatments were far from satisfactory.

It was noted in the course of these investigations that mercury was lost by volatilization from a cor-

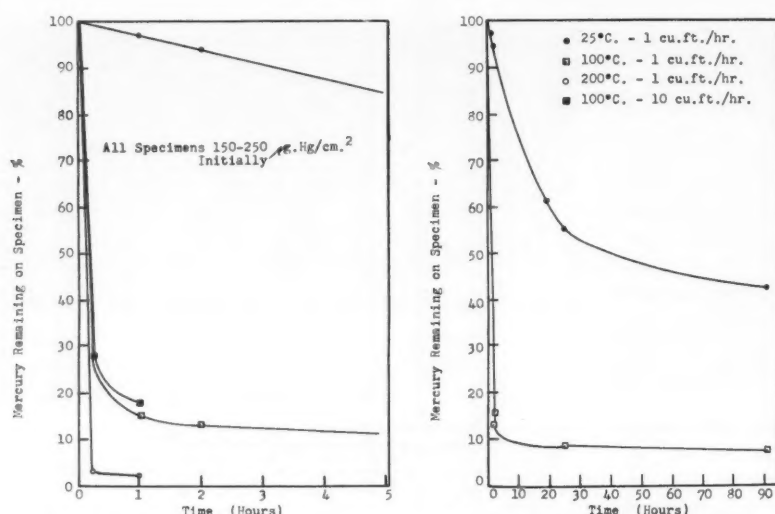


Figure 16—Removal of mercury from corroded aluminum surface by vaporization in air.

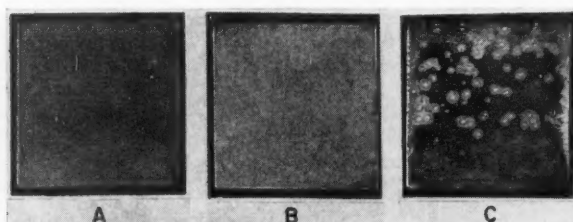


Figure 17—Photographs showing effect of heating on reducing pitting type of attack in 3½ percent NaCl (two weeks). Sample in photograph A is not contaminated, B is contaminated and heated one hour at 100 C and C is same as B but not heated.

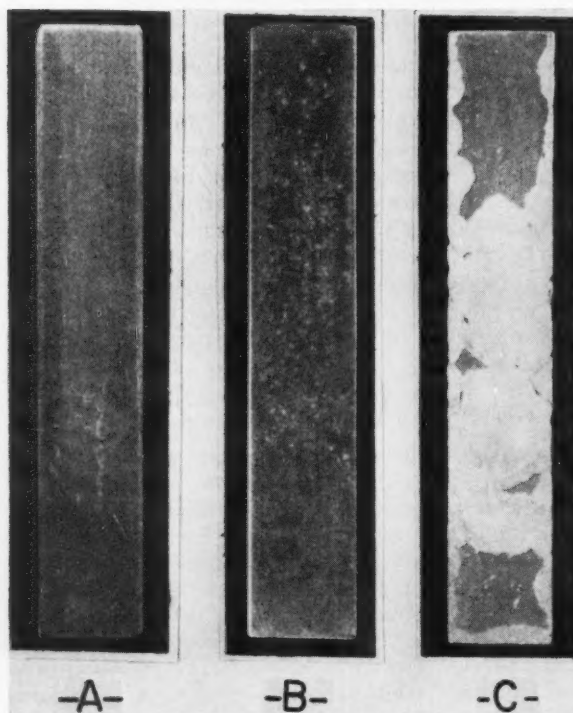


Figure 18—Specimens exposed to 5 percent acetic acid for 24 hours under the following conditions: A—No mercury contamination; B—Contaminated, heated 100 C for one hour; C—Same as B but not heated.

roded aluminum specimen allowed to stand in the air. In order to determine the dependence of rate of loss on temperatures and air flow, specimens were exposed to a radioactive mercury solution and placed in a tube heated with a sleeve furnace. The rate of loss as a function of time was then determined.

It is seen from Figure 16 that an increase in temperature greatly accelerates the loss, but an increase in air flow above 1 cubic foot/hour had no effect. It would seem that heating a specimen in free air to as high a temperature as possible is a satisfactory way to remove mercury, other things being equal. Tests were performed to see how effective the volatilization treatment was for removing mercury from specimens allowed to stand

for 65 days to give the mercury a chance to diffuse into the aluminum. Heating for one hour at 150 C removed 98 percent of the mercury; it was concluded that long delay before removal does not retard cleaning. It was found that steam at 150 C removed mercury as well as air at 150 C.

Some experiments were performed to demonstrate that aluminum specimens contaminated with mercury were less susceptible to corrosion after heating in air. The results are shown in Figures 17 and 18.

In one experiment, specimens of 1100-H14 aluminum alloy were exposed to 100 ppm of mercuric chloride for two hours. Half of the specimens were heated at 100 C for one hour and the specimens were exposed to 3.5 percent sodium chloride for two weeks. The contaminated and cleaned specimens lost two to five times as much weight as specimens that had not been contaminated. Specimens that had been contaminated but not cleaned lost three to four times as much weight as those that had been cleaned. Figure 17 shows that the cleaning treatment substantially reduced the pitting type of attack.

The results of a second experiment in which specimens were exposed to 5 percent acetic acid are shown

TABLE 1—Chemical Cleaning of Mercury from Corroded 3003 Aluminum

Cleaning Agent ¹	$\mu\text{g. Hg/cm}^2$	% Removal
Distilled H ₂ O.....	208 256	8 11
5% Na ₂ CrO ₄	202 262	18 11
5% Na ₂ Cr ₂ O ₇	264 222	22 31
5% HNO ₃	235 23	85 52
5% CrO ₃	212 24	92 84
70% HNO ₃	270 200	100 100

¹ Twenty-four hours at room temperature.

in Figure 18. The contaminated specimens (in 100 ppm Hg^{++} as $HgCl_2$ for 24 hours) that had been heated for one hour at 100 C lost four to eight times the weight of non-contaminated specimens. Contaminated specimens which had not been heated lost more than 30 times as much weight as specimens that had been heated.

It was further demonstrated that corrosion could be reduced as effectively on specimens that had been contaminated and then stored for times up to one week as on specimens that were heated immediately.

The results of these laboratory tests suggest that the susceptibility to corrosion of aluminum process equipment which has been accidentally contaminated by mercury might be substantially decreased by heating in air or dry steam. For special applications, the chemical stripping treatments given in Table 1 might be applicable.

The volatilization of mercury from aluminum surfaces poses a problem in cases where analyses are made on specimens from corroded equipment in order to determine the cause of corrosion. It is apparent in terms of the high rate of loss by vaporization that mercury contamination on corroded specimens exposed to air for several days will either go undetected or only trace amounts will be found. A convenient method of preventing such loss would be to spray a sample with a plastic resin as it was removed from the system. An evaluation of one such spraying technique is shown in Figure 19.

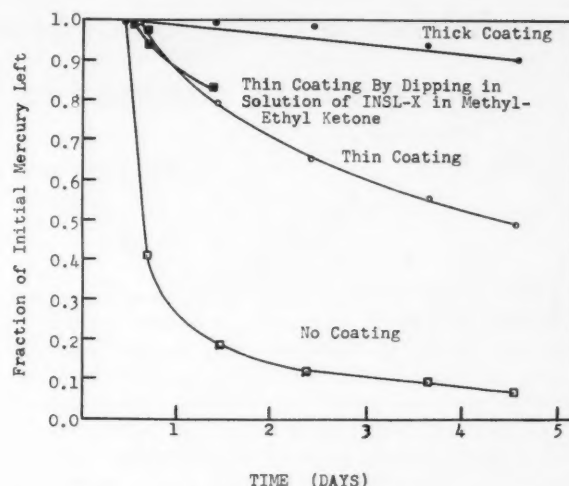


Figure 19—Rate of loss of mercury from corroded aluminum specimens coated with acrylic resin by spraying from INSL-X pressurized bomb.

References

1. M. H. Brown, W. W. Binger, and R. H. Brown. Mercury and Its Components, A Corrosion Hazard. 8th Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952; *Corrosion*, **8**, 155-164 (1952).
2. J. D. Edwards, F. C. Frary, Z. Jeffries. The Aluminum Industry II, 54, McGraw-Hill Book Company (1930).
3. C. Quillard. *Compt. Rend.*, **185**, 953 (1927).
4. Radiosotopes in the Study of Metal Surface Reactions. Institute of Metals Monograph No. 13.
5. P. M. Aziz, *J. Elec. Soc.*, **101**, No. 3, 120 (1954).
6. R. C. Plumb. *Rev. Sci. Inst.*, **26**, No. 5, 489-493 (1955).

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will appear in the December, 1956 issue.**

% Removal
8
11
18
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Inhibiting Corrosion of Steel, Aluminum and Magnesium Intermittently Exposed to Brines*

By GEORGE E. BEST and JOHN W. McGREW

Introduction

THE EFFECTIVENESS of chromate for preventing metallic corrosion in a wide variety of aqueous media is becoming well known from the many publications on this subject which have appeared over the years. A veritable classic among examples that might be given is the application of chromate in sodium and calcium chloride refrigerating brines. The use of the material in this connection represents one of the first instances of chemical inhibitor utilization to come into recognized use.^{1,2} For the most part, however, both experimental and practical inhibitor applications have involved virtually continual contact between the metal and the liquid exposure medium. Under such a condition a reserve of inhibitor is always available to be delivered to the metal-liquid interface.

Inhibitors also have received some attention for purposes where exposure is intermittent. Thus chromate has been effective in mitigating corrosion of automotive equipment by de-icing salt^{3,4} and in reducing the severity of attack of stainless steel dyeing equipment by hot chloride solution.⁵ Furthermore, chromate has been considered on the basis of favorable experimental evidence for preventing aircraft corrosion by de-icing salts,⁶ for minimizing internal corrosion in tankers,⁷ and for overcoming the harmful effects of refrigerator car brine drippings on both rolling stock and trackage.⁸ There may be other possibilities of potential interest (e.g., natural brines flowing discontinuously).

The purpose of the present investigation was to obtain experimental information about the ability of chromate to inhibit the corrosive action of sodium and calcium chloride brines under a condition of intermittent exposure.

Testing Procedure

Brines

Brine concentrations of 1, 2.5, 5, 10, and 25 percent weight were employed in these tests. Sodium chloride brines were prepared with commercial rock salt. In Baltimore tap water uninhibited brines ranged from pH 7 to 8. Calcium chloride brines were prepared from commercial flake calcium chloride. The commercial product regularly contains a slight excess of lime (uninhibited solutions ranged from a little below pH 8 to a little above pH 9). Brine volume initially was 150 ml, but subsequently was increased to one liter.

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Abstract

Prevention of corrosion of metals under continuous exposure to sodium or calcium chloride refrigerating brine is one of the earliest commercial applications of a chemical inhibitor. Yet comparatively little has been published about the effectiveness of inhibitors under conditions of discontinuous exposure.

An experimental technique designed only to provide comparative data and indicate orders of magnitude rather than precisely determined corrosion rates is used. Experiments establish that chromate effectively minimizes brine corrosion of mild steel and selected aluminum and magnesium alloys intermittently exposed to brines at ordinary temperatures. The importance of ratio between metal surface area and test solution volume is brought out, as is also the effect of pH through comparison of chromate with bichromate. Roughly quantitative indications of inhibitor consumption are reported.

Metals

Steel used was SAE-AISI 1020 20 gage (0.0375 inch thick). Initially strips 15.5 inches long and 0.75 inch wide, completely encircling the plastic hexagons, were used (see Figure 2). Subsequently 2.5 x 0.75 inches panels were employed. A description of metals used is given below:

Aluminum: 2S (99.0 + percent Al)
3S (1.2 percent Mn)
24S (4.5 percent Cu, 1.5 percent Mg,
0.6 percent Mn)

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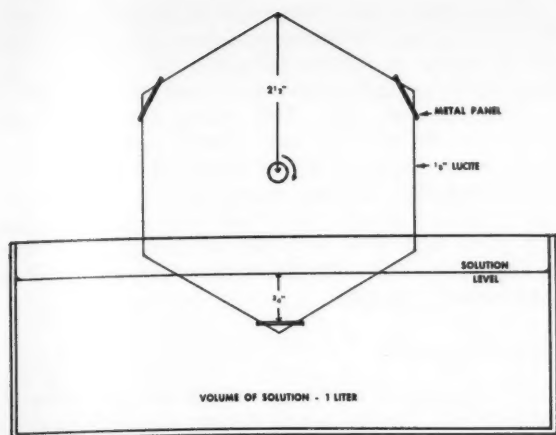


Figure 1—Line sketch of testing apparatus.

75S (5.5 percent Zn, 2.5 percent Mg, 1.5 percent Cu, 0.3 percent Cr, 0.2 percent Mn)

Size of Panels: 2.5 x 0.75 x 0.040 inches

Magnesium: FS-1 alloy—ASTM AZ31X (3 percent Al, 1 percent Zn, 0.3 percent Mn)

Size of Panels: 2.5 x 0.75 x 0.040 inches

R alloy—ASTM AZ91 (9 percent Al, 0.7 percent Zn, 0.2 percent Mn)

Size of Panels: 2.5 x 0.75 x 0.091 inches

Inhibitors

Technical grade sodium chromate (Na_2CrO_4) and sodium bichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$) were used as inhibitors. Chemically, chromate differs from bichromate only in regard to pH; both contain chromium in the hexavalent form. Chromate dissolves to give mildly alkaline solutions (pH 8.4 at 0.1 percent concentration in distilled water) whereas bichromate solutions are on the acidic side (pH 4.5 at 0.1 percent). In solution bichromate instantly converts to chromate upon addition of alkali as is shown in the following equation:



One hundred parts $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ are equivalent to 108.7 parts Na_2CrO_4 . Obviously alkaline substances other than caustic soda would also serve to convert bichromate.

It is important to understand that comparisons between chromate and bichromate are comparisons of moderately different pH levels only. Bichromate could have been used throughout, with alkali added for conversion to chromate whenever desired. This was not done because: (1) In operating practice the user has the option of applying either chromate or bichromate, both being regularly available, and (2) Both testing and interpretation of results are simplified by using the two chemicals. Where large amounts of inhibitor are involved, however, the lower unit cost of bichromate, either with or without alkali, can be a determining factor in the selection.

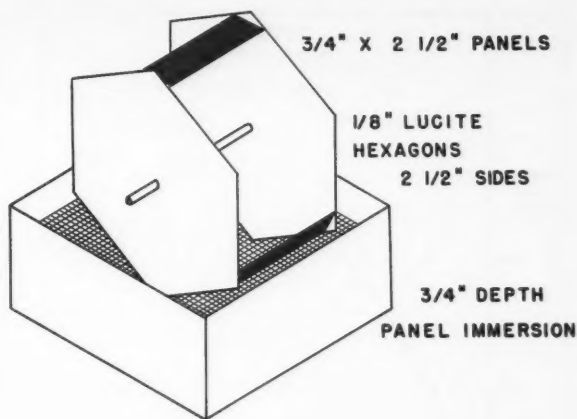


Figure 2—Schematic view of testing apparatus.

It was decided arbitrarily to relate the amount of inhibitor employed to the sodium or calcium chloride solids rather than to specify inhibitor concentration independently. This was done from a consideration of cost and practicality in projected use. In addition to this, comprehension of results was simplified.

Chemical analysis of test brines was carried out to provide for maintaining inhibitor concentration at the predetermined level. From experience it was learned that lower concentrations (referring to the range of 100 to 2500 ppm involved in these tests) required daily analysis and adjustment, whereas every three days was adequate for the higher concentrations. Records were kept of the amounts of inhibitor added, the total thus representing the quantity consumed during the course of the test.

Reference was made earlier to initial use of a steel strip of specified dimensions and a test brine volume of only 150 ml. This averages out to about 1050 sq cm of exposed specimen area per liter of solution. Under this condition the inhibitor concentration decreased rapidly in some instances and even disappeared completely overnight as judged by loss of color. This inability to control inhibitor concentration satisfactorily led to decreasing metal surface area by the use of small panels and to increasing the brine volume to one liter. Tests were made either with two or three panels, representing ratios of about 52 and 77 sq cm per liter, respectively. Using multiple panels was advantageous in that weight losses could be compared; a test result was taken only if the two or three panels showed reasonably good agreement.

Test Apparatus

Figures 1 and 2 illustrate schematically the device used to obtain periodic exposure of the metal specimens to the brine solutions. The panels were held between pairs of thin plastic hexagons, ten sets of which were mounted on a horizontal shaft. Slots were not put in the plastic because of the possibility of trapping brine. Panels were held by end pressure exerted by adjusting the hexagons with set-screw hubs on the shaft.

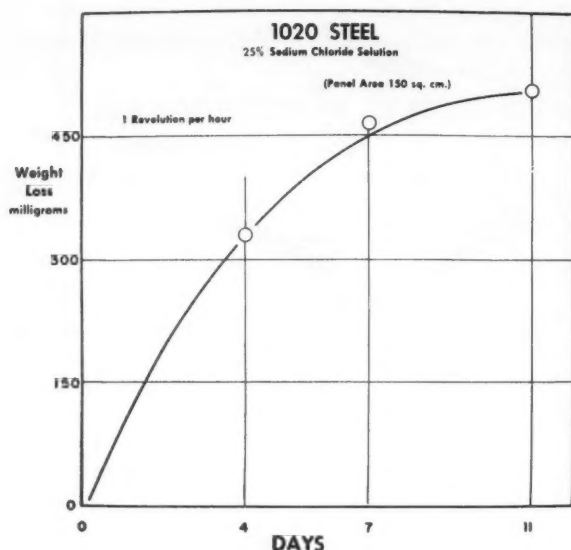


Figure 3—Determination of test duration.

Test brines were contained in rectangular glass dishes located so that the maximum immersion of the metal panels would approximate 0.75 inch and the immersion period would be about one-quarter of the rotational cycle. This rotary corrosion tester proved to be an extremely simple and satisfactory unit for the purpose. It was driven by a synchronous motor having a torque rating of only 8 ounces at one inch radius at 1 rpm. This was adequate when the panel load was balanced as illustrated. A shaft counter indicated any electrical interruption during unattended intervals.

Speed of Rotation

At 0.2 rpm the panels remained wet continuously. At 0.05 to 3 rpm the panels became dry in appearance just as they were about to re-enter the solution. At 1 rph drying took about one-quarter of the cycle. This speed was chosen and the specimens were accordingly cycled hourly as follows:

- 0.25 hour: Immersion
- 0.25 hour: Drying
- 0.50 hour: Dry (in appearance)

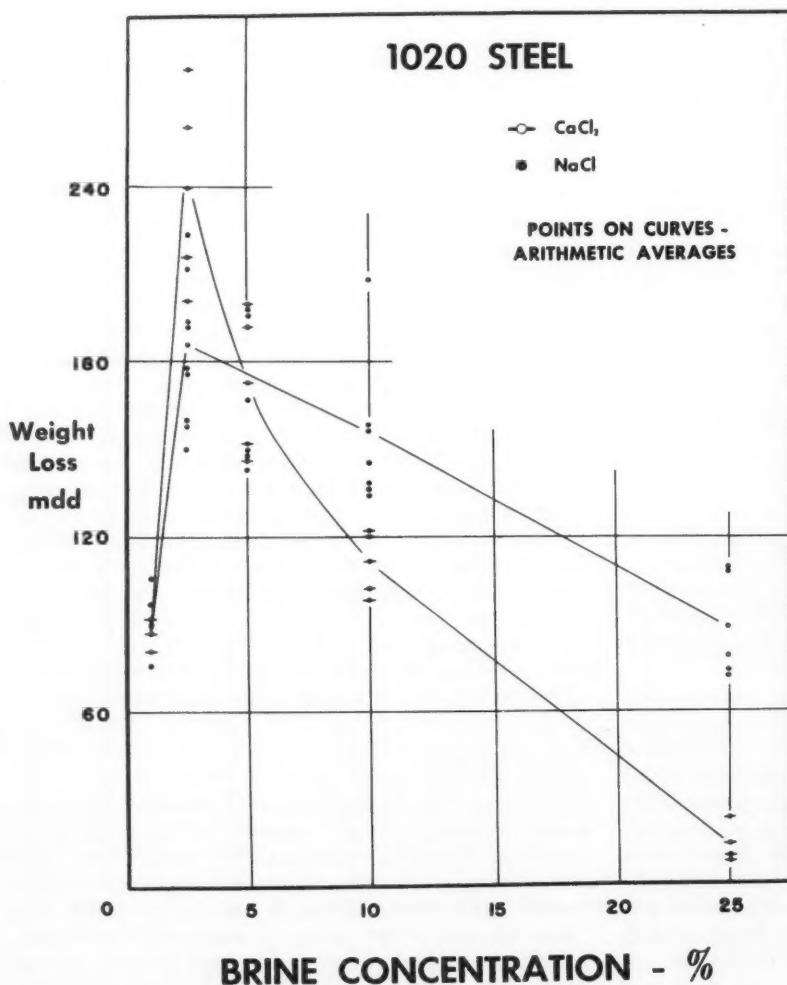


Figure 4—Corrosion of 1020 steel in calcium and sodium chloride brines.

Test Duration

It is common knowledge that brief exposure to an inhibitor frequently leads to unreliable results. The reason for this is that initial behavior in establishing a protective condition differs from long term behavior which is usually the point of significance.

Figure 3 shows the results of preliminary tests made to indicate how long the testing period should be. A period of 15 days was chosen in order to obtain data not having a high degree of sensitivity from the standpoint of time.

Experimental Results

Steel

The spread of weight loss values shown in Figure 4 is intended to emphasize that the results were not precisely reproducible. Variations in both temperature and humidity of the laboratory atmosphere were to some degree responsible for the erratic data obtained. Examination of the data in retrospect reveals that the higher points at each brine concentration came from tests made in the summer months when the air was warmer and more humid. Figure 5 and those to follow were based on what was believed to be the most significant data but should be taken as indicating only orders of magnitude for purposes of comparison.

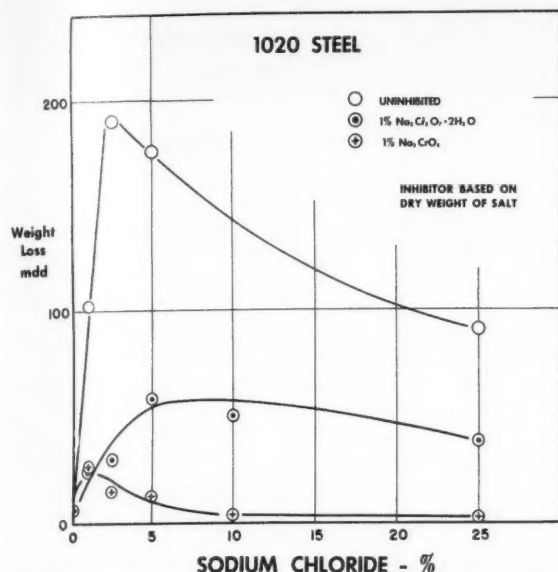


Figure 5—Inhibiting corrosion of 1020 steel in sodium chloride brines with hexavalent chromium at different pH levels.

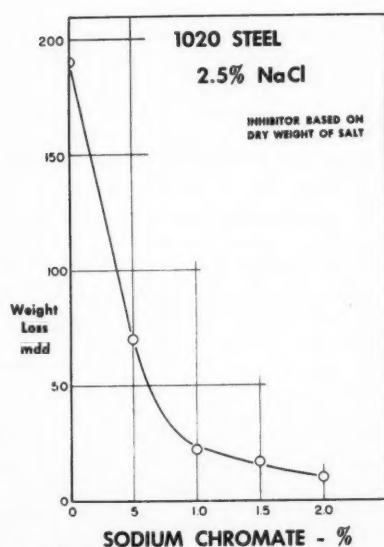


Figure 6—Inhibiting corrosion of 1020 steel with chromate at most corrosive sodium chloride concentration.

Figure 4 shows sodium and calcium chloride brines in the vicinity of 2.5 percent concentration were more corrosive to steel than either more dilute or more concentrated brines. At this level of maximum corrosivity, calcium chloride was more corrosive than sodium chloride. At 1 percent brine strength the two materials exhibited about the same corrosion rate. Above 2.5 percent, the corrosiveness of calcium chloride brines decreased more rapidly with increasing concentration than that of sodium chloride; at 10 percent and at 25 percent strengths sodium chloride

INHIBITOR CONSUMPTION (Solutions maintained daily)			
NaCl	Initial Bichromate Concentration	pH	Bichromate Consumed
1 %	100 ppm	6.4	0.099 grams
2.5	255	5.7	0.178
5	518	5.3	0.382
10	1070	4.9	0.355

1020 STEEL

Figure 7—Consumption of bichromate in inhibiting 1020 steel.

INHIBITOR CONSUMPTION (Solutions maintained daily)			
NaCl	Initial Chromate Concentration	pH	Chromate Consumed
2.5	127 ppm	7.5	0.209 grams
2.5	255	7.7	0.142
2.5	380	7.8	0.145
2.5	510	7.9	0.112

1020 STEEL

Figure 8—Consumption of chromate in inhibiting 1020 steel.

brines were more corrosive than calcium chloride.

From Figure 5 it is apparent that the higher pH imparted by chromate was distinctly beneficial to inhibiting corrosive attack by sodium chloride. In this connection it can be seen that 1 percent chromate greatly decreased corrosion in dilute brines and essentially eliminated it above 5 percent brine strength, as compared to limited inhibition with 1 percent bichromate. At 5 percent brine concentration, chromate gave pH 7.8 whereas bichromate dropped the pH to 5.3.

Figure 6 shows the effect of varying the amount of chromate at the most corrosive brine level. The presence of 0.5 percent was significantly effective, although much less so than 1 percent. Above 1 percent the gain in metal protection was relatively much smaller.

Details of inhibitor consumption are given in Figures 7 and 8 with initial inhibitor concentrations as analyzed values. For the bichromate series, the amount consumed is a function of both the corrosiveness of the brine and the lowering of pH; the amount consumed increased steadily until at 10 percent brine strength the inhibitor concentration reached a point

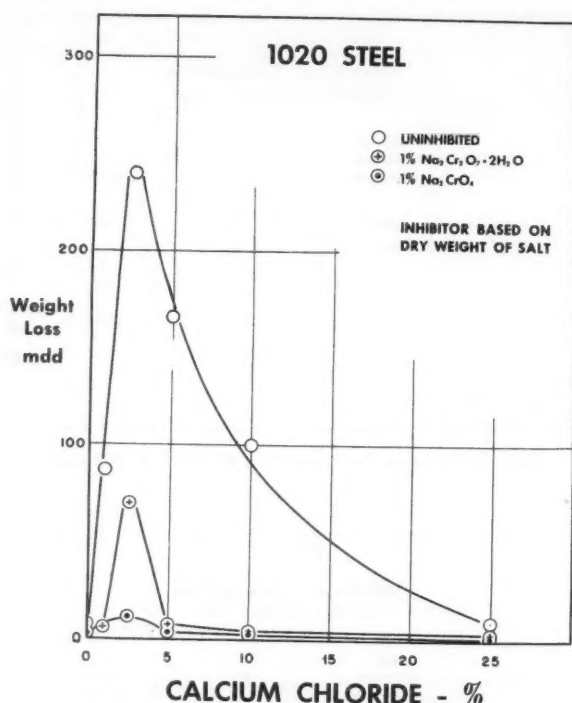


Figure 9—Inhibiting corrosion of 1020 steel in calcium chloride brine with hexavalent chromium at different pH levels.

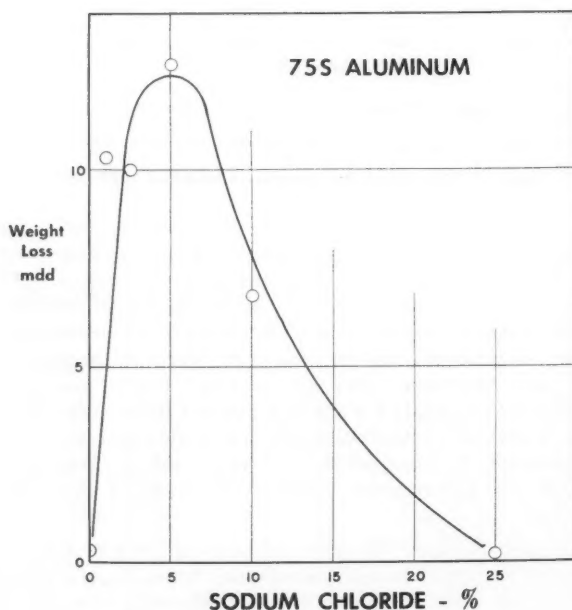


Figure 10—Corrosion of 75S aluminum in sodium chloride brines.

of diminishing the rate of attack. The chromate series (Figure 8) exhibited a trend which might be expected from other corrosion studies,⁹ namely, a decreasing amount consumed as the inhibitor concentration increases.

Direct comparison of bichromate versus chromate consumption is available only at 2.5 percent brine

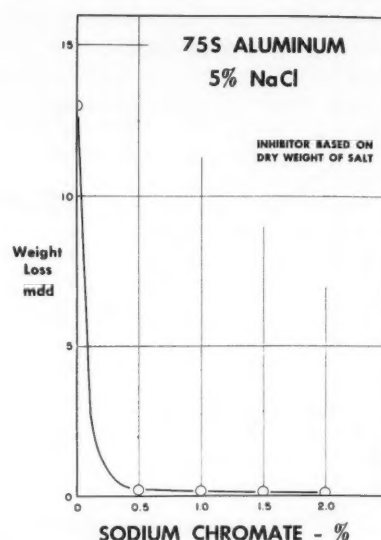


Figure 11—Inhibiting corrosion of 75S aluminum with chromate at most corrosive sodium chloride concentration.

strength where the degree of protection afforded was roughly the same (see Figure 5). At the lower pH (5.7 in Figure 7) of the bichromate solution about one-third more hexavalent chromium was consumed than with chromate at pH 7.7 (see Figure 8).

From Figure 9 it is apparent that in calcium chloride brine at the most corrosive strength (2.5 percent), the presence of 1 percent bichromate, while markedly decreasing rate of attack, was inadequate to provide a high degree of inhibition. It was, however, almost completely protective at both higher and lower brine strengths. Increasing the pH, as represented by using chromate instead of bichromate, overcame this deficiency and prevented appreciable corrosion at all levels of calcium chloride concentration.

Aluminum

It was found that 2S and 3S aluminum were virtually unattacked by sodium chloride over the entire range of brine concentrations. This was not true of 24S, but unfortunately data cannot be presented because no method of removing corrosion products was found which did not result in metal attack. For this reason the weight loss values were unreliable.

Figure 10 shows that 75S aluminum was similar to steel, with a peak corrosion rate at 5 percent brine strength. However, the maximum rate of attack was less than one-tenth that of the maximum rate of attack on steel. A 0.5 percent addition of chromate stifled this corrosion, as shown in Figure 11.

This program was interrupted before tests were completed on aluminum in calcium chloride brines. It would be erroneous to assume that behavior there would necessarily parallel that in sodium chloride solutions.

Magnesium

The two magnesium alloys tested, R and FS-1,

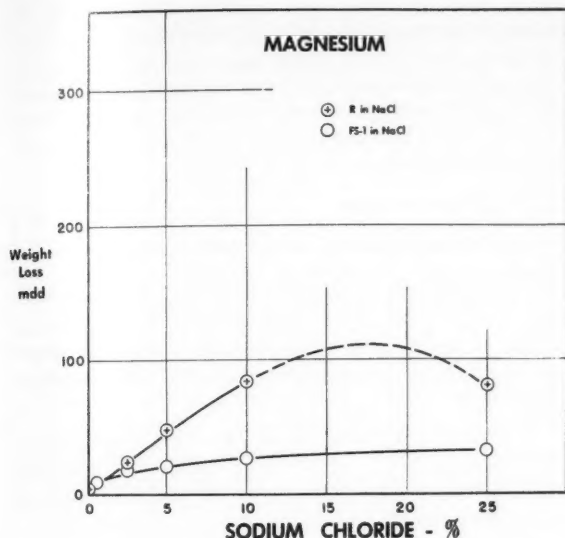


Figure 12—Corrosion of magnesium alloys R and FS-1 in sodium chloride brines.

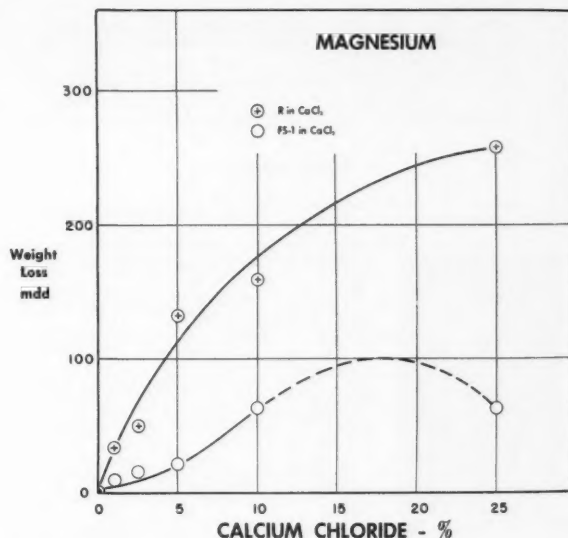


Figure 13—Corrosion of magnesium alloys R and FS-1 in calcium chloride brines.

behaved in a different manner from steel in that corrosive attack increased generally with increasing brine concentration. In addition to this calcium chloride brines were definitely more corrosive than sodium chloride brines—see Figures 12 and 13. The R alloy was more readily attacked than the FS-1 alloy in either brine. However, even 0.5 percent chromate furnished a high degree of protection to both alloys at all levels of brine concentration (see Figure 14).

Summary and Conclusions

A rotary corrosion tester was devised for cyclically exposing small metal panels so that they were immersed about one-quarter of the time, drying one-quarter, and dry (in appearance) one-half the time. Tests were carried out using sodium and calcium chloride brines ranging from 1 percent to 25 percent in concentration with a cycle period of one hour. Test duration was 15 days. The influence of chromate and of bichromate on corrosion rate was determined, use of the two materials serving as a simple means of testing hexavalent chromium at different pH levels with the chromate yielding higher pH than the bichromate. The data are intended to indicate orders of magnitude and serve for comparison purposes rather than to provide precisely determined corrosion rates.

Results obtained under these conditions of test led to the following observations:

1. Attack on SAE-AISI 1020 steel by either sodium or calcium chloride was greatest in the vicinity of 2.5 percent brine strength; at this concentration calcium chloride was more corrosive than sodium chloride. At higher brine concentrations the corrosiveness of calcium chloride decreased more rapidly with increasing concentration; at 10 percent and 25 percent sodium chloride, brine was more corrosive than calcium chloride.

Chromate was compared to bichromate as a simple and practical means of testing the inhibition afforded by hexavalent chromium at different pH

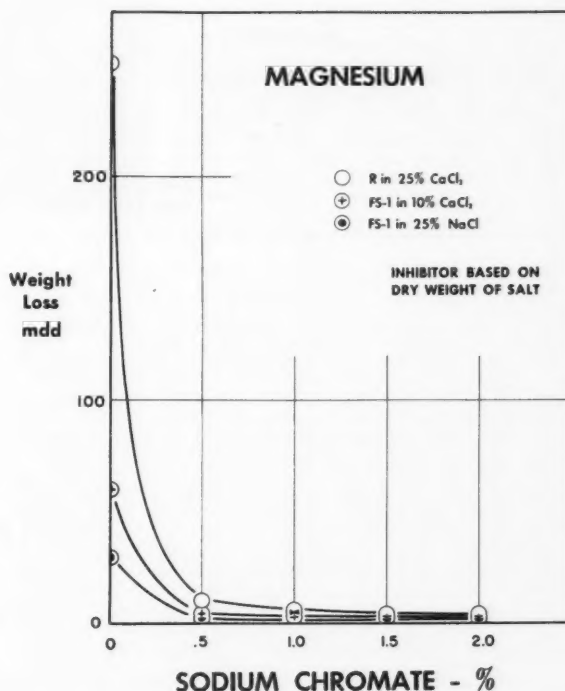


Figure 14—Inhibiting corrosion of magnesium alloys R and FS-1 in calcium and sodium chloride brines with chromate.

levels. The addition of 1 percent sodium chromate—based on sodium or calcium chloride solids—effectively minimized corrosive attack. A like amount of sodium bichromate (i.e., lower pH) was less effective, but moderated corrosion considerably. Also, less hexavalent chromium was consumed in the case of chromate. Accordingly on both counts the inhibitor was more efficient at the higher pH level.

2. 2S and 3S aluminum were not significantly corroded by sodium chloride at any brine strength. 75S aluminum was attacked at a low rate, less than one-tenth that of the maximum on steel, and 0.5 percent chromate was adequate to stifle it.

3. Magnesium R and FS-1 alloys differed from both steel and aluminum in that corrosion generally increased as brine strength increased. Calcium chloride was more corrosive than sodium chloride, and R alloy more susceptible to attack than FS-1 alloy. An addition of 0.5 percent or more chromate afforded nearly complete protection.

References

1. Corrosion in Refrigerating Plants, American Society of Refrigerating Engineers, Circular No. 10 (1930).
2. Marc Darrin, Chromate Corrosion Inhibitors in Brine Systems, 1944 American Society of Refrigerating Engineers Corrosion Report (1945).
3. M. L. Davis, Street Cleaning—Snow Removal. *Engineering News-Record*, **143**, 35-36 (1949) Oct. 20.
4. Chemicals for a Clear Road. *Chemical Week*, **72**, 62, 65, 67 (1953) Jan. 24.
5. F. N. Speller, Severe Pitting of Stainless (18-8) Steel in Hot Chloride Dye Baths. *Corrosion*, **11**, 31 (1955) July.
6. Jerome Lederer, Winterization of Airport Facilities—Corrosion of Aircraft by Calcium Chloride. *Aero Digest*, **59**, 49-51 (1949) August.
7. W. B. Jupp, J. V. C. Malcolmson et al. Control of Internal Corrosion of Tankers. *Trans. Soc. Naval Architects & Marine Engrs.*, **60**, 382-441 (1952).
8. G. M. Magee, Testing Inhibitors of Brine Drippings Corrosion of Railway Tracks and Equipment. *Corrosion*, **7**, 186-88 (1951) June.
9. Marc Darrin, Chromate Corrosion Inhibitors in Chloride Systems. *Ind. Eng. Chem.*, **38**, 368-75 (1946) April.

Appendix

Unsatisfactory procedures for the preparation of

panels for corrosion tests included: (1) dipping or wiping with organic solvent, (2) solvent followed by scrubbing with a brush in hot one pound/gallon Na_3PO_4 solution. Neither method gave surfaces which would wet quickly and uniformly when the panels entered the test brines. A satisfactory procedure consisted of the following steps:

1. Solvent wiping
2. Ten-minute boil in 0.25 pound/gallon Na_3PO_4
3. Scrubbing with generous amount of precipitated chalk using a clean damp cloth

The procedure for cleaning panels after corrosion test preparatory to weighing is given below for three materials:

1. Steel—alternate brushing with brass-bristled brush and boiling in 5 percent ammonium citrate solution until surface exhibits uniform high luster.
2. Aluminum—boiling in 5 percent phosphoric acid—2 percent chromic acid solution to constant weight.
3. Magnesium—immersion in saturated chromic acid solution at room temperature up to an hour.

Any discussions of this article not published above will appear in the December, 1956 issue.

The Scaling of Titanium and Titanium-Base Alloys in Air*

By HAL W. MAYNOR, JR. and ROY E. SWIFT

Introduction

THE DESIRABLE combination of properties exhibited by titanium has resulted in its rapidly increasing application in many fields. The temperatures at which its performance is satisfactory are limited, however, by its tendency to scale and to absorb oxygen, nitrogen and hydrogen. Absorption of these elements causes undesirable changes in the metal's mechanical properties. The purpose of this investigation was to evaluate the influence of a series of alloying additions to titanium in order to provide a basis for selection of alloy systems offering the greatest promise of improved oxidation resistance.

Previous Investigations

Relatively little information relating to the oxidation of titanium is to be found in the literature. A summary of work completed prior to 1952 was presented by Morton and Baldwin¹ in connection with their study of the scaling of commercial titanium at temperatures of 930 to 2370 F (500 to 1300 C). They reported the presence of TiO and TiO₂ in scales after relatively long exposures in this temperature range. The scaling characteristics of titanium from three different sources were substantially different. Changes in the kinetics of the scaling reaction were found to occur with time at constant temperature. Increasing oxygen pressure was found to reduce the temperature or time required to produce such changes, although below 1560 F (860 C) this effect was not observed in air.

Walden and Dixon² conducted an investigation of the effect of prior heating on the microstructure and mechanical properties of commercial titanium (RC-70). Results obtained indicated that annealed titanium may be employed for applications involving very short exposures (30 minutes maximum) to temperatures up to 1500 F (815 C) in air.

McPherson and Fontana^{3,4} studied the scaling characteristics of titanium-base alloys containing, respectively, 4 percent, 11 percent, and 17 percent chromium in still air at 1600 F (870 C) during the course of an investigation of the properties of titanium-chromium alloys. These investigators showed that additions of chromium up to 16 percent deleteriously affect the oxidation resistance of titanium at elevated temperatures. The differential in oxidation resistance of these alloys and stainless steel was appreciable, the latter being superior to the former.

Welter et al⁵ investigated certain properties of commercially pure titanium, and binary, ternary, and quaternary titanium-base alloys. A limited study of the oxidation resistance of certain of these alloys was conducted over the temperature range of 1112-1652 F (600 to 900 C). A ternary alloy containing 1 percent Cu, two percent Ni-Ti and a quaternary alloy con-

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ROY E. SWIFT—Associate professor of mining and metallurgical engineering at the University of Kentucky. He has engineering degrees from the Missouri School of Mines, University of Washington, University of Utah and Yale University. Dr. Swift is a member of several professional and scientific societies and is a registered professional engineer in the fields of mining, metallurgy and chemistry.

Abstract

A preliminary study of the scaling characteristics in air of laboratory-produced titanium and titanium-base alloys, and commercially-produced titanium and titanium-base alloys was conducted at temperatures of 1200, 1400, 1600, and 1800 F (650, 760, 870, and 980 C) in the time range of approximately 4 to 300 hours. A total of 43 titanium-base alloys, one commercial grade of titanium (RS-70), and AISI Type 302 stainless steel were scaled at each of these temperatures; two additional alloys were employed at temperatures of 1200 and 1600 F. Scales formed on a 4.02 percent Al-Ti alloy were studied in detail and a scaling mechanism was suggested; scales formed on a 4.03 percent Cr-Ti alloy and a 2.95 percent W-Ti alloy were studied in less detail. Scaling tendencies of titanium-base alloys, relative to titanium and stainless steel were evaluated on the basis of weight gain with time. Isothermal transitions in scaling rate were observed for titanium and titanium-base alloys within the temperature range 1200-1600 F.

taining 0.2 percent Si, 1 percent Fe, 1.8 Cb-Ti were found to be relatively resistant to scaling on the basis of weight gain versus time.

Havekotte⁶ described a study of titanium carbide-base cermets. Weight-gain values obtained from 200 hours exposure at 1800 F (980 C) in an atmosphere containing moist air varied from 12.4 to 47.6 mg per square cm for the six different compositions employed.

Jenkins⁷ investigated the oxidation of titanium in the temperature range 1112-1697 F (600-925 C) at an oxygen pressure of 700 mm of mercury. In certain

* Submitted for publication August 8, 1955.

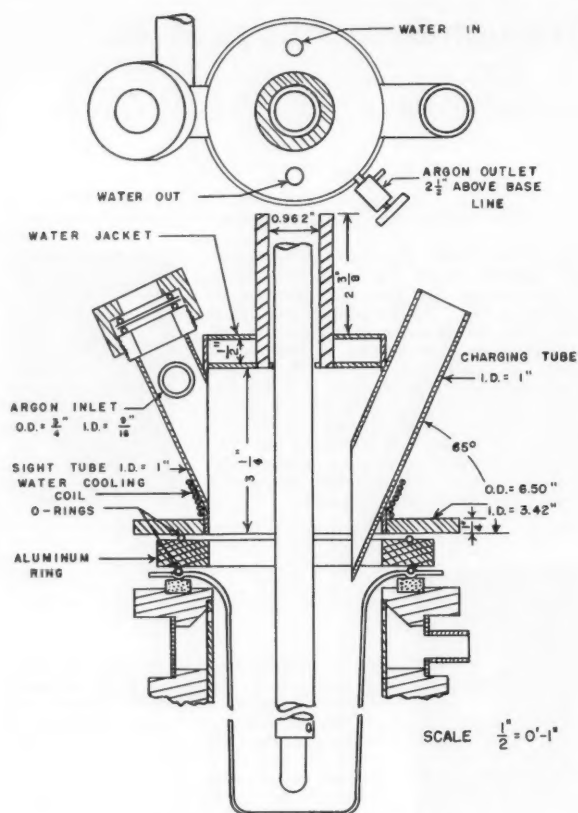


Figure 1—Vacuum arc furnace (modified).

TABLE 1—Chemical Composition of Binary and Ternary Titanium-Base Alloys

Analysis of Binary Alloys (Weight Percent)	Analysis of Ternary Alloys (Weight Percent)
3.28 Al-Ti	3.69 Si-Ti
1.21 Al-Ti	1.03 Si-Ti
2.95 W-Ti	4.45 Cb-Ti
1.13 W-Ti	1.00 Cb-Ti
4.13 Ni-Ti	1.23 Mo-Ti
0.91 Ni-Ti	4.48 Al-Ti
4.03 Cr-Ti	
1.05 Cr-Ti	1.99 Ni-1.01 Cu
4.11 Mn-Ti	6.45 Al-0.87 Si
1.27 Mn-Ti	0.94 Al-1.21 W
3.76 Fe-Ti	3.95 Ta-1.20 Si
0.93 Fe-Ti	4.05 Cr-1.03 Mn
3.34 Cu-Ti	4.05 Ta-1.00 Cb
0.95 Cu-Ti	4.27 W-0.82 C
3.88 V-Ti	0.98 Cr-0.98 Fe
0.84 V-Ti	1.95 W-0.92 Si
4.37 Ta-Ti	3.99 Al-1.02 W
0.54 Ta-Ti	4.01 Ta-0.98 W
3.96 Mo-Ti	0.74 Mo-3.30 W
1.19 Mo-Ti	

TABLE 2—Chemical Composition of Commercial Titanium and Titanium-Base Alloys

Manufacturer	Manufacturer's Designation	Composition
Rem-Cru Titanium	RC-130A RC-130B	8% Mn, balance Ti 4% Mn, 4% Al, balance Ti
Republic Steel	RS-70 RS-110A	Ti 4% Cr, 2% Fe, balance Ti
Mallory-Sharon	MST-3% Al, 5% Cr MST-2.5% Fe, 2.5% V MST-2.5% Fe, 2.5% V MST-2.5% Al, 2% Fe	1.93% Al, 5.38% V, balance Ti 2.67% Fe, 2.68% V, balance Ti 2.28% Fe, 2.55% V, balance Ti 2.19% Al, 3.45% Fe, balance Ti

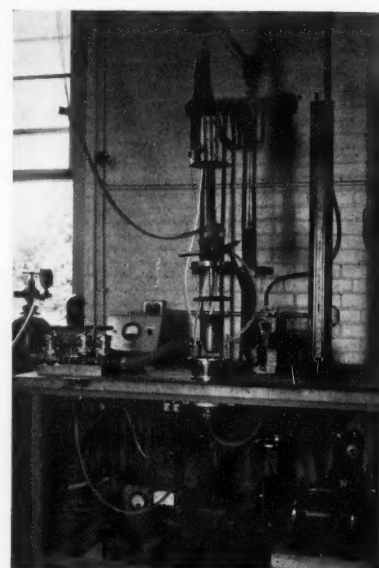


Figure 2—Arc-melting furnace (disassembled) and auxiliary equipment.

TABLE 3—Composition of Titanium Sponge and Alloying Elements

Element	Weight (Percent)	Form	Supplier
Ti	99.8	Sponge	E. I. duPont de Nemours Company
Fe	0.06		
Mg	0.03		
O ₂	0.06		
Ni	0.01		
Cu	99.965	Fine shot	Mallinckrodt Chemical
Al	99.698	8-20 Mesh and finer	J. T. Baker Chemical Company
Si	99.85	Massive	Electro Metallurgical Division, Union Carbide and Carbon Corporation
V	99.7	Slugs	Vanadium Corporation of America
Cb	....	Sheet	Fansteel Metallurgical Corporation
Ta	....	Sheet	Fansteel Metallurgical Corporation
Cr	99.3187	3/4 inch cathode chips	Electro Metallurgical Division, Union Carbide and Carbon Corporation
Mo	....	Sheet	Fansteel Metallurgical Corporation
W	99.9	80 Mesh plus fines	Fansteel Metallurgical Corporation
W	....	Wire (0.020 inch diameter; Type NS 30)	Fansteel Metallurgical Corporation
			Sylvania Electric Products, Incorporated
Mn	99.9	1/4 inch cathode chip	Electro Manganese Corporation
Fe	99.9	No. 30 B&S gauge wire	J. T. Baker Chemical Company
Ni	99.88	Shot	Mallinckrodt Chemical Works

instances the distribution of oxygen between scale and metal and the character of the oxidation products were investigated. A mechanism was suggested for the oxidation of titanium at high temperatures.

Program

In order to evaluate the influence of selected alloying elements on the scaling characteristics of titanium an experimental program was initiated permitting comparison of arc-melted alloys, commercially pure titanium, and AISI Type 302 stainless steel. The following steps were involved:

1. Selection of alloy compositions.
2. Alloy preparation.
3. Specimen preparation.
4. Scaling rate measurements.
5. Observation of scale characteristics.

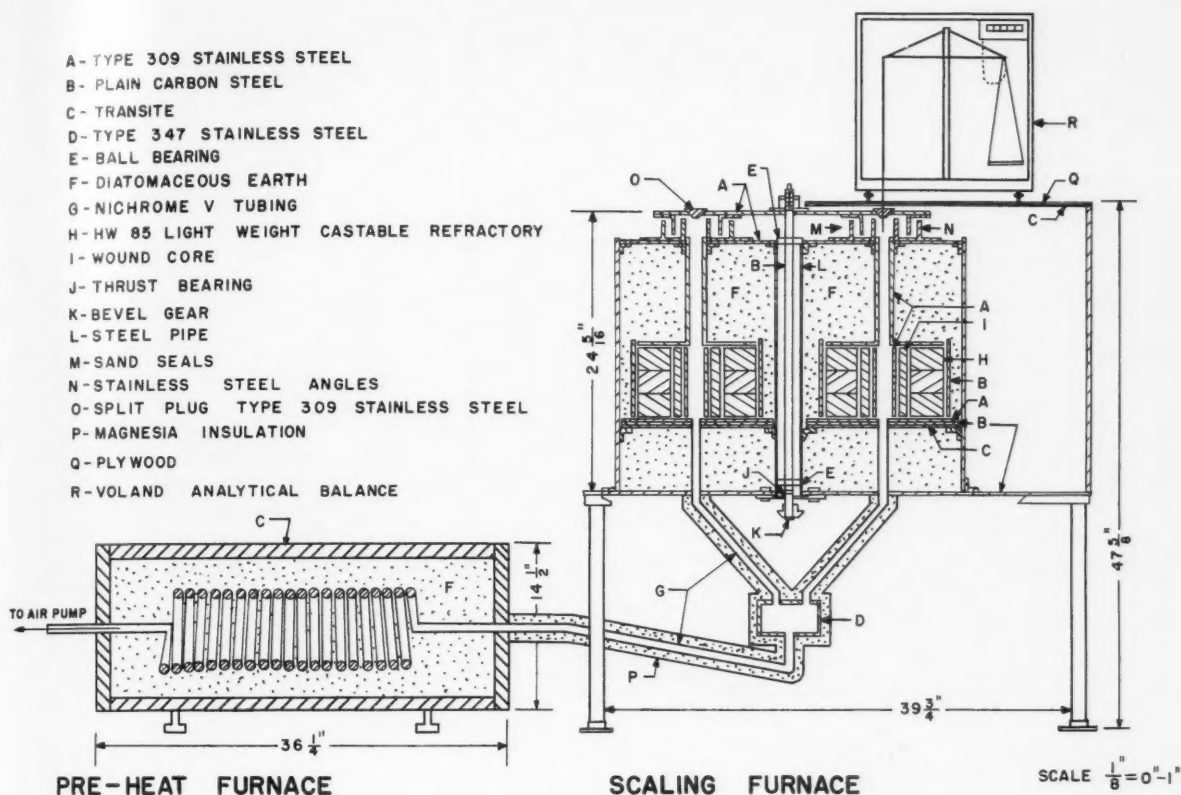


Figure 3—Components of scaling equipment.

Selection of Alloy Compositions

Twelve alloying elements were selected for addition to titanium. Compositions of binary and ternary alloys are shown in Table 1. Table 2 lists the compositions of commercial titanium and titanium alloys employed.

Alloy Preparation

Materials

Compositions of titanium sponge and alloying elements (except carbon) are shown in Table 3.

Arc-melting Furnace

Ingots of titanium and titanium-base alloys were produced utilizing an arc-melting furnace of approximately one pound capacity. The furnace was designed on the basis of drawings of an arc-melting furnace supplied by L. W. Eastwood and previously used by Eastwood et al.^{8,9} at the Battelle Memorial Institute. Inasmuch as this type of furnace has been employed by a number of investigators, it is sufficient to state that its essential features consisted of a tungsten-tipped water-cooled electrode, a water-cooled copper crucible, and a water-cooled head or cover. The furnace is shown in Figures 1 and 2.

Specimen Preparation

The specimens were prepared as follows:

1. Alloying additions were mixed with coarse,

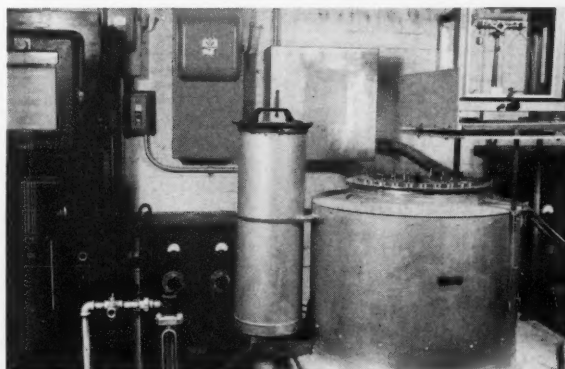


Figure 4—Scaling furnace and auxiliary equipment.

TABLE 4—Data Associated With Rate Discontinuities

Temperature	Time	Value of X in Equation (1)
1200 F.	To 1 hour	1.07
1200 F.	1 hour—140 hours	0.5 (average value)

methanol-leached titanium sponge and melted in a flowing argon atmosphere.

2. Ingots were forged at temperatures generally ranging from 1750 to 1950 F, sandblasted, sheared and remelted.
3. Twice-melted ingots were radiographed be-

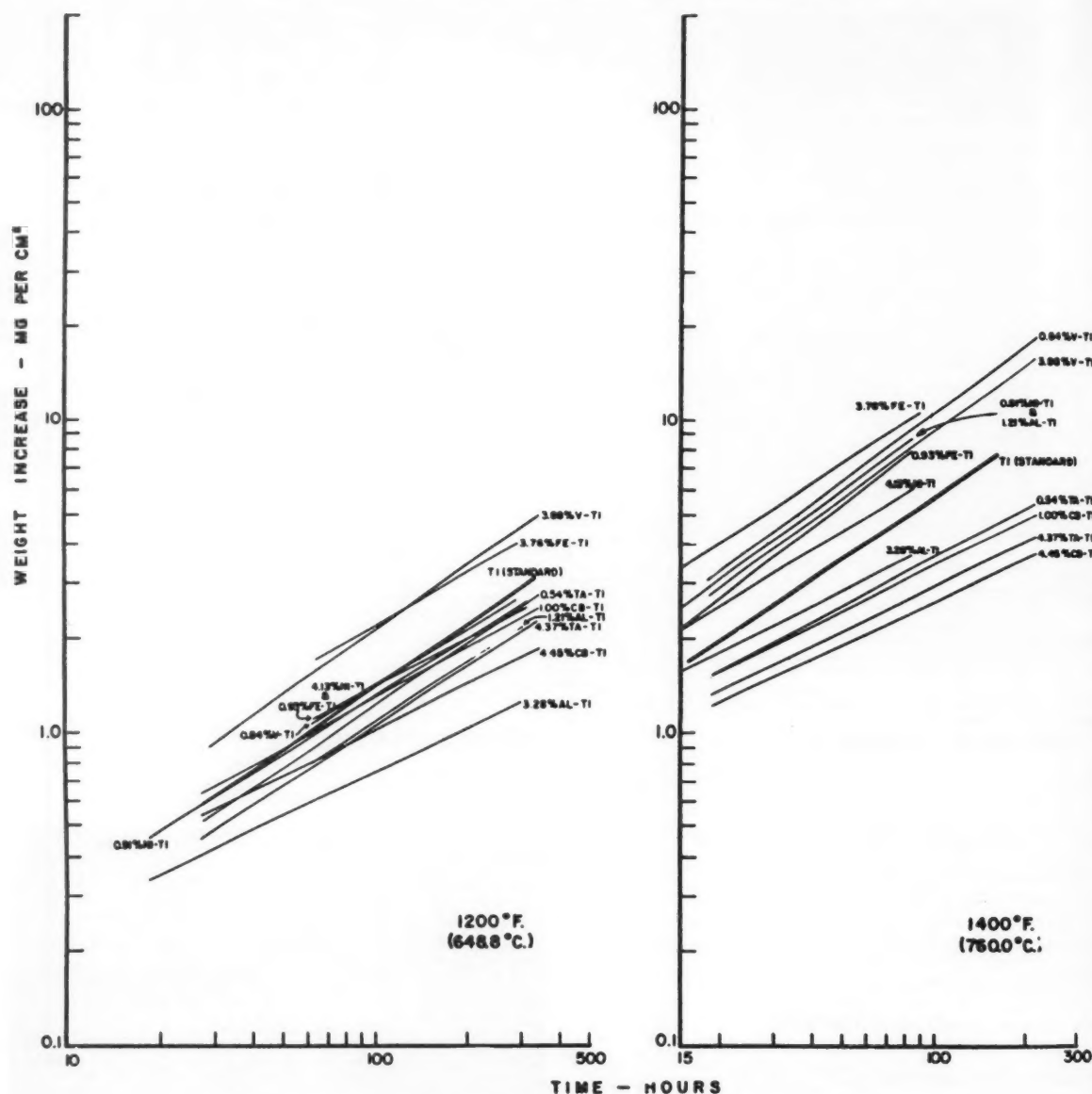


Figure 5—Weight increase per unit original area as a function of time for binary alloys at 1200 and 1400 F.

fore and after forging. If inhomogeneity were indicated they were remelted. Homogeneous ingots were forged, rolled, sand-blasted and ground to final specimen dimensions of 1 inch x 2 inches x 0.045-0.050 inch.

4. Specimens were slotted or drilled to permit suspension in the scaling furnace.

Comparison of radiographic and metallographic examinations of homogeneous and inhomogeneous ingots substantiated the effectiveness of radiography in detecting gross amounts of undissolved additions even when a similarity in atomic number and density existed. Chemical analyses further confirmed the technique.

Tungsten contamination resulting from deteriora-

tion of the electrode tip was difficult both to control and to determine. Variations in analytical determinations prevented a satisfactory evaluation of its effect on individual alloys.

Scaling Rate Measurements

Scaling Furnace

The scaling furnace employed in this investigation incorporated features of a furnace employed by Day and Smith¹⁰ in their investigation of the scaling of iron alloys. This furnace (Figures 3 and 4) was essentially an annular muffle formed by refractory brick and transite. The furnace comprised a 36 KVA transformer and Nichrome V windings which were mounted on externally and internally wound cores.

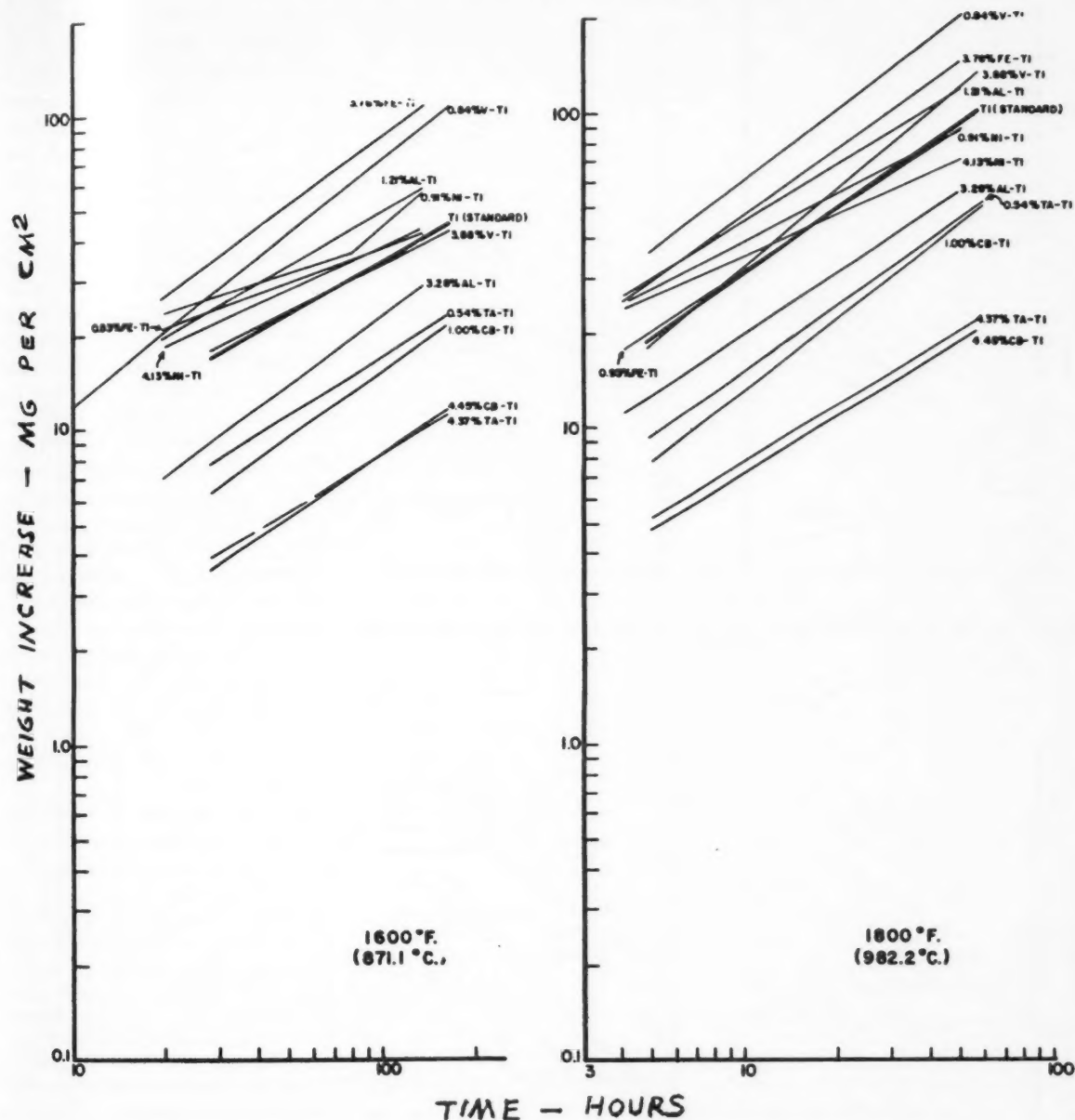


Figure 6—Weight increase per unit original area as a function of time for binary alloys at 1600 and 1800 F.

A rotating top provided for 25 specimens suspended from Nichrome V ribbons.

A pre-heat furnace was employed to heat air (1.7 cfm) supplied to the scaling furnace at 400-500 F. This furnace was composed of a helical coil of Nichrome V tubing which served as a resistance heater and carrier of the air, and a transite cylinder. The functions of pre-heated excess air were: (1) To provide a relatively simple means of ensuring a uniform atmosphere, and (2) To promote the formation of titanium oxide rather than titanium nitride. A chemical balance was mounted above the scaling furnace and at intervals rotation of the top was discontinued and the specimens were weighed in place. This pro-

cedure eliminated the specimens otherwise required for intermediate weight-gain determinations, and generally prevented the spalling of scale from specimens.

Methods Employed in the Determination of Scaling Resistance

Weight-gain data were obtained by observing, periodically, the isothermal increase in weight of specimens exposed to elevated temperatures for various periods of time.

Because of the high solubility of oxygen in titanium it was desirable to determine the distribution of oxygen between the metal and the scale. Attempts

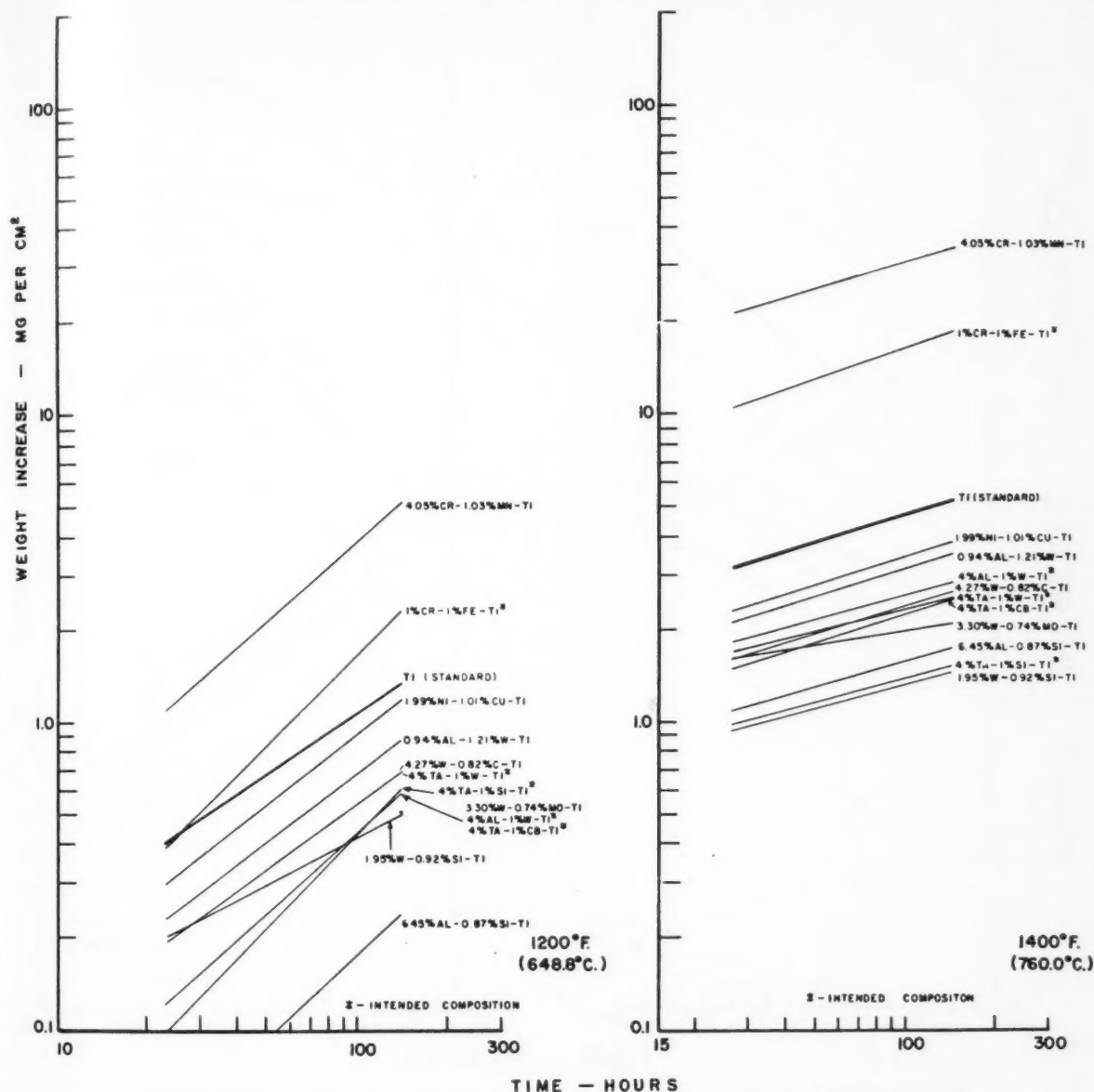


Figure 9—Weight increase per unit original area as a function of time for ternary alloys at 1200 and 1400 F.

considerably more difficult to prepare because of their extreme brittleness. Specimens which had been exposed for approximately 50 hours to the temperature of 1800 F were scaled so extensively they could not be utilized in the determination of penetration-rate data.

Scaling Rate Data

Principal evaluation of scaling resistance on the basis of weight-gain data was adopted in preference to weight-loss and penetration-rate data for the following reasons:

1. Satisfactory separation of scale and metal was not possible.
2. The scale-metal interface was so irregular

that penetration measurements were subject to error.

Evaluations of the relative scaling tendencies of titanium and titanium-base alloys were conducted on the basis of weight gain resulting from exposure of these materials to temperatures of 1200, 1400, 1600, and 1800 F.

Figures 5, 6, 7, and 8 show the weight-gain results for binary alloys, Figures 9 and 10 for ternary alloys, and Figures 11 and 12 for commercial alloys. The unalloyed titanium standards used are the average of four separate heats. Figures 13 and 14 compare selected curves from preceding figures with Type 302 Stainless Steel.

The relationship between weight gain and time

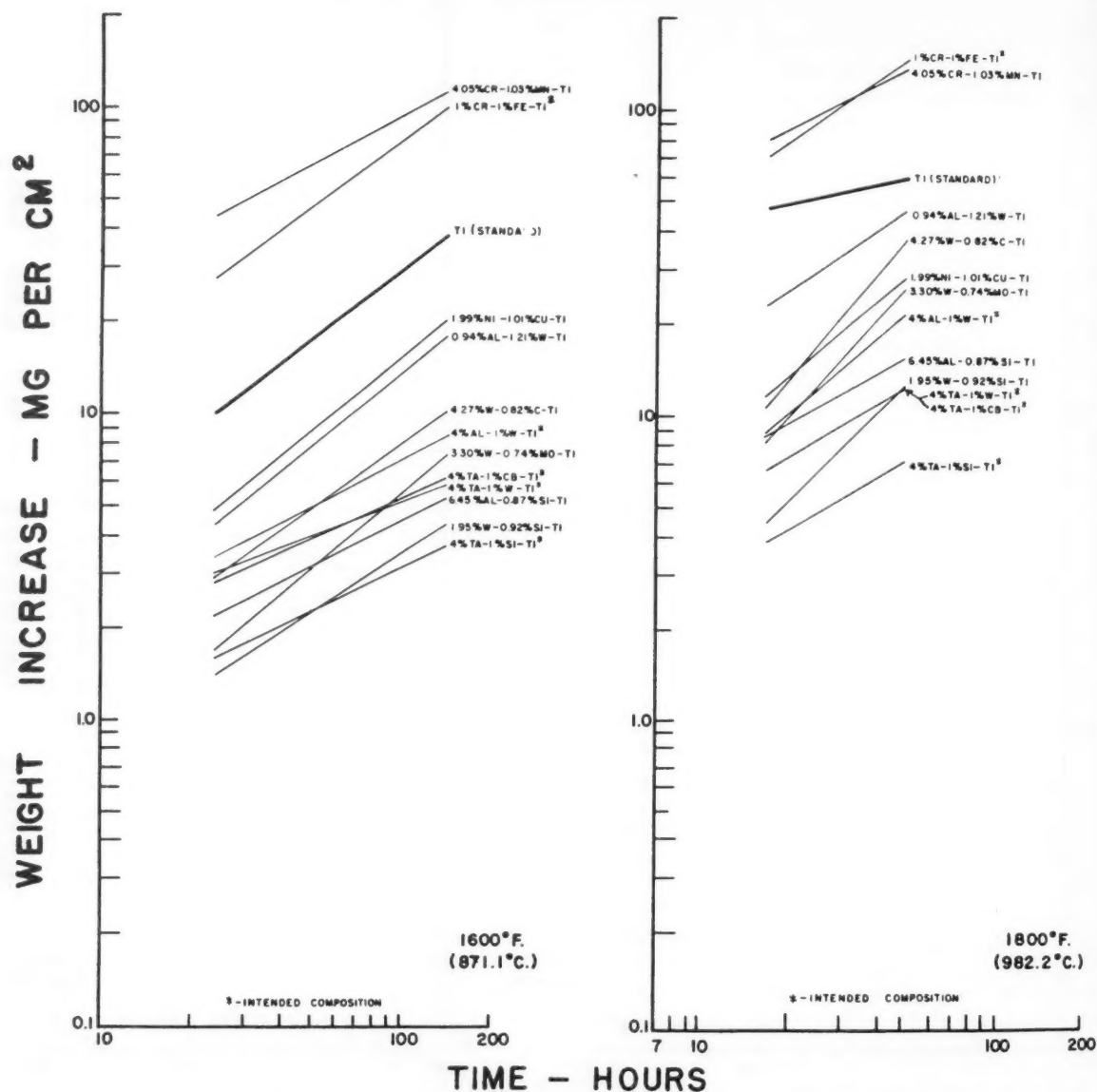


Figure 10—Weight increase per unit original area as a function of time for ternary alloys at 1600 and 1800 F.

was found to follow an equation of the type:

$$w = (Kt)^x \quad (1)$$

where: w = weight gain per unit area
 K = rate constant
 t = time
 x = slope

Transitions in scaling rate were observed for one heat of unalloyed titanium. The data associated with these rate discontinuities are shown in Table 4.

Transitions in rate were observed for alloys containing 3.96 percent Mo at 1400 F, 1.19 percent Mo at 1600 F and 0.91 percent Ni at 1600 F, but were not studied in detail.

Efforts to correlate the weight gain results in terms of an Arrhenius-type equation by plotting weight gain at constant time as a function of reciprocal absolute temperature yielded neither straight

lines nor consistent results for similar materials. This behavior was attributed to the following factors:

1. Influence of alloy composition on the distribution of oxygen between scale and metal.
2. Variations in a complex scaling mechanism which yielded layers of different colored scales.

The characteristics of the scaling process of titanium observed in this study differ from those reported by Morton and Baldwin¹ in the following respects:

1. Morton and Baldwin¹ noted the occurrence of a transition at about one hour which took the form of a shift in the value of K rather than the exponent, x .

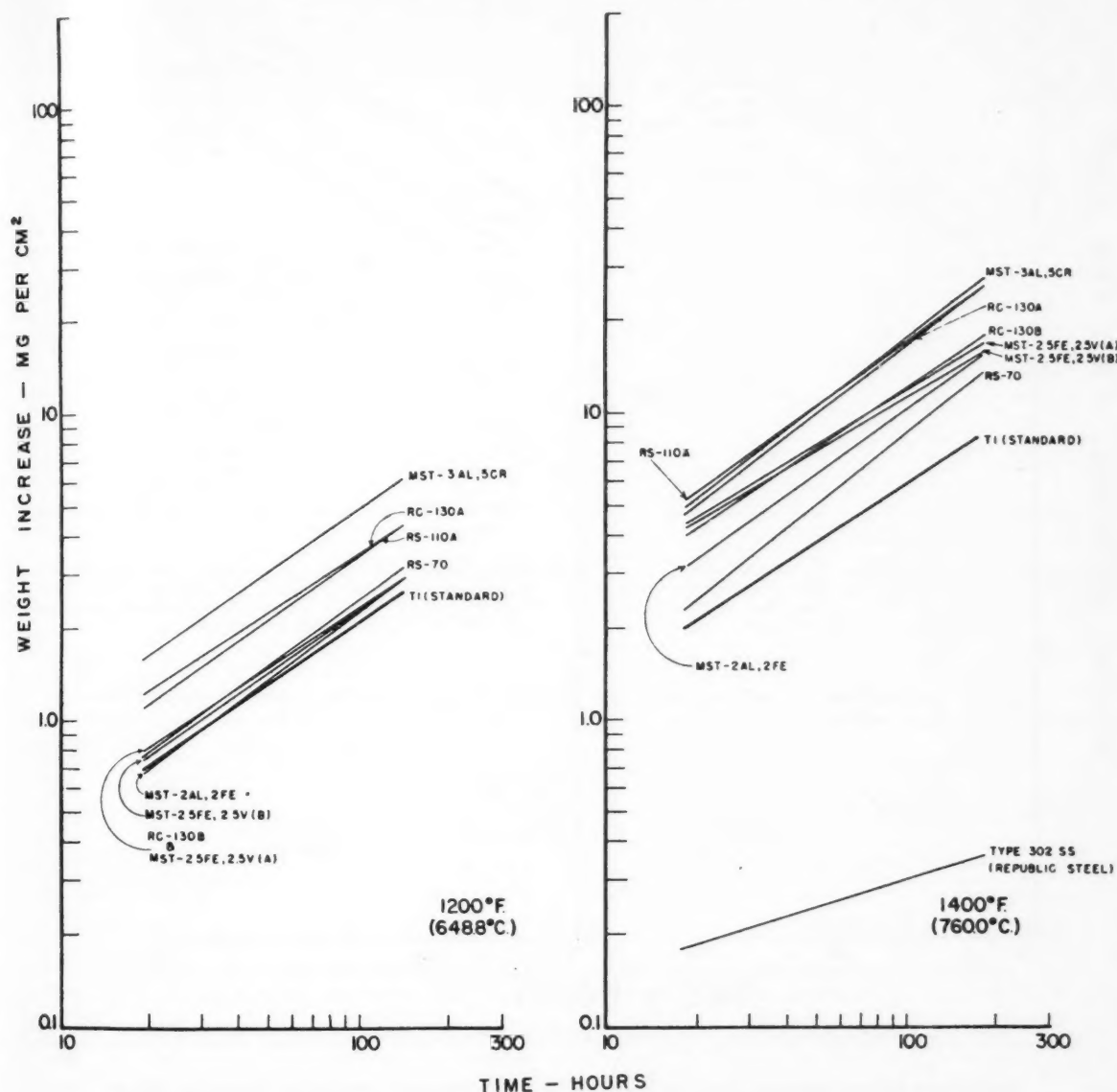


Figure 11—Weight increase per unit original area as a function of time for commercial alloys at 1200 and 1400 F.

2. The scaling rate observed in this study was appreciably higher at times below one hour.
3. Morton and Baldwin¹ reported the rate transition to occur at 1830 F. The transitions noted for comparable material in this investigation occurred at 1200 F.

Resolution of these differences probably lies in more detailed analyses of the scaling process for titanium of commercial purity.

Observation of Scale Characteristics

Scales formed on three alloys were selected for detailed study as to alloying element distribution. The description and composition of the scales studied are shown in Tables 5, 6, and 7.

4.02 Percent Al-Ti Alloy

The aluminum-titanium alloys showed good oxidation resistance and it was anticipated that examination of the scale would indicate the manner in which aluminum contributed.

The scale formed on the 4.02 Al-Ti alloy, as shown in Table 5, was composed of several layers having a rutile structure but differing in color. The number of layers varied with the time and temperature of exposure. A comparison of the scales formed on this alloy with scales formed on titanium revealed no essential differences other than those of a dimensional nature. At a depth of 0.005 inch below the scale-metal interface (toward the center of the specimen) the aluminum concentration was reduced from 4.02 percent to 3.37 percent.

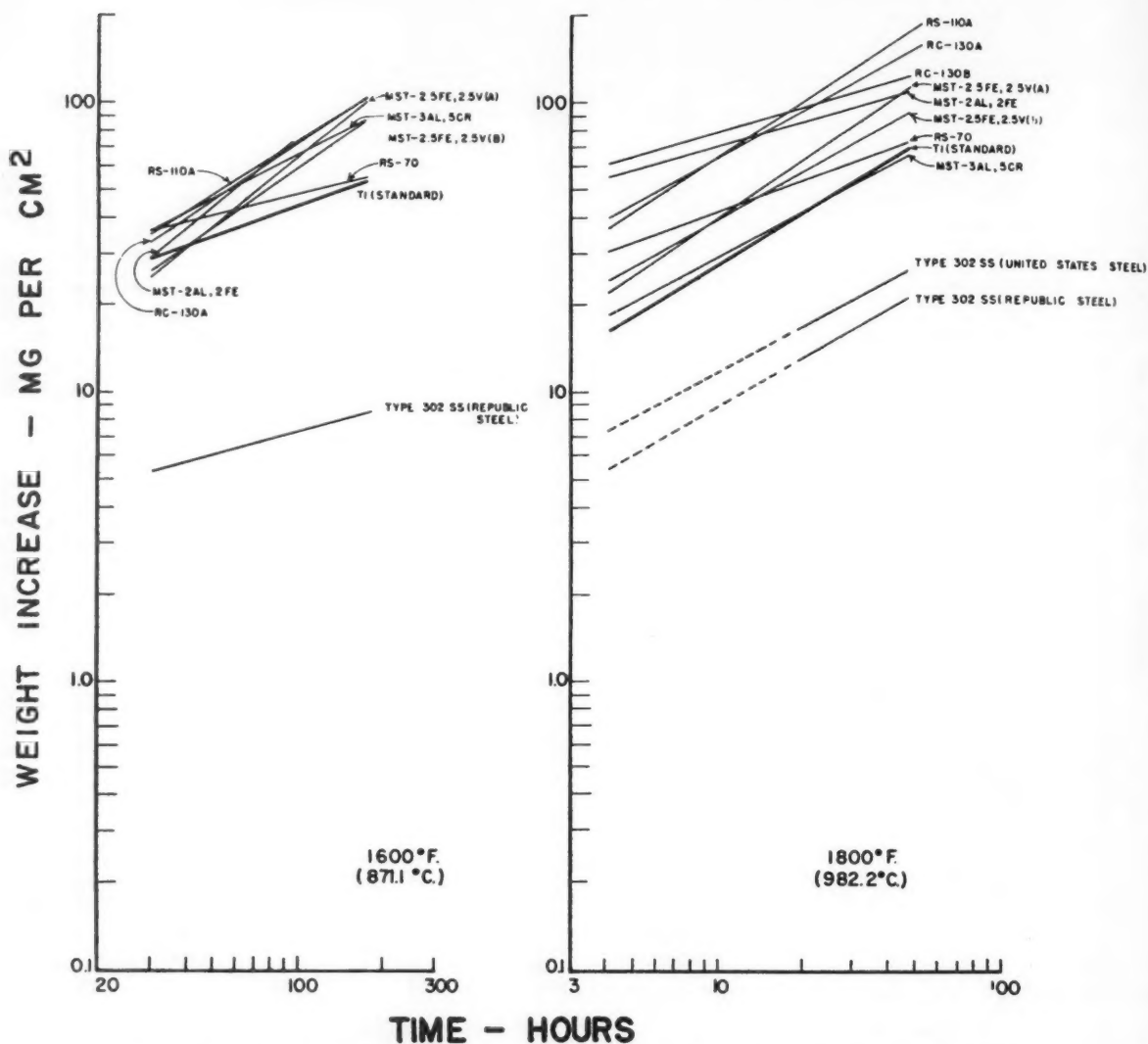


Figure 12—Weight increase per unit original area as a function of time for commercial alloys at 1600 and 1800 F.

TABLE 5—Characteristics of Scale Formed on 4.02 Percent Aluminum-Titanium Alloy¹

Temperature (Degrees F)	Time (Hours)	No. of Strata	Sequence ² and Color	Form, Thickness	Diffraction Pattern	Aluminum Analysis	Remarks
1200	2	1	Light Bronze	Metallic, about 0.0001 cm	Alpha ³	Not done	.....
1200	300	2	Light Blue Gray	0.0008 cm 0.0003 cm	Rutile ⁴	Positive ⁴	Very hard, adherent
1400	2	2	Green Gray	0.0006 cm 0.0004 cm	Rutile ⁴	Positive ⁴	Very hard scale, adherent
1400	72	2	Gray-green Gray	Small crystals, 0.0010 cm Two phase, 0.0028 cm	Rutile Rutile and Alpha	Positive ⁴	Adherent scale
1600	2	3	Yellow Light Gray Dark Gray		Rutile ⁴	Not done	No micro exam.; scale too friable; spalls readily
1600	120	5	Brown White Gray Silver-gray Light Gray	Granular, 0.0043 cm Friable, 0.0007 cm Two phase, 0.0049 cm Two phase, 0.0049 cm One phase, 0.0011 cm	Rutile Rutile Rutile Rutile Rutile	Negative Negative Positive Positive Positive	Scale adherent but cracks and spalls under external pressure
1800	1.5	5	Brown White Silver-gray Gray White	Fine Grain, 0.0690 cm Powder, 0.0663 cm Two phase, 0.0047 cm Powder, two phase, 0.0111 cm Powder, fine, 0.0005 cm	Rutile Rutile Rutile Rutile Rutile	Negative Negative Positive Positive Negative	Scale spalled upon air cooling

¹ Scales appearing on specimens exposed at 2000 F were the same as those at 1800 F except for dimensional variations.² Sequence of strata is from outside toward metal.³ Solid solution of O₂ in Ti.⁴ Composite scale specimens.

2.95 Percent W-Ti Alloy

The influence of tungsten, an element having a volatile oxide, was considered to be of interest because theoretical considerations had indicated that the effect of tungsten in solution in the oxide of titanium should be to reduce the concentration of oxide ion vacancies in the latter.¹¹ Consequently, scales formed on tungsten alloys were studied and were found to be stronger and much harder than any of the scales investigated. No powdery layers such as were observed in other instances were found to be present. All strata appeared to be extremely adherent. X-ray diffraction studies again revealed the existence of only one crystal structure—rutile. Qualitative analyses weakly indicated the presence of tungsten in all strata.

Conclusions

The curves of Figures 5-14 constitute a detailed summary of the results of this investigation. Comparison of the behavior of the alloys as a function of temperature leads to the following conclusions:

1. Binary and ternary laboratory-produced titanium-base alloys generally became increasingly superior to titanium on exposure to progressively higher temperatures in the range of 1200 to 1800 F.
2. Commercial binary and ternary titanium-base alloys scaled at increasingly greater rates than titanium on exposure to temperatures in the range 1200 to 1800 F.
3. Alloys showing better scaling rates, on a weight-gain basis, than Type 302 stainless steel throughout the temperature range were:
 - a. 4 percent Ta, 1 percent Si
 - b. 4 percent W, 1 percent Si
 - c. 6 percent Al, 1 percent Si
4. Alloys showing consistently poor scaling resistance at all temperatures were:
 - a. 4 percent Cr, 1 percent Mn
 - b. 1 percent Cr, 1 percent Fe
 - c. 1 percent Cr
 - d. 4 percent Cr
5. Comparison of data for a series of unalloyed titanium heats prepared and tested under essentially identical conditions revealed significant differences, indicating the sensitivity of the rate of oxidation of titanium to relatively small variations in composition and history.
6. A transition in the scaling rate of titanium was observed between 1 hour and 1.5 hours at a temperature of 1200 F.
7. X-ray diffraction studies of scales revealed only oxides of rutile structure at room temperature after prior exposure to temperatures within the range 1200 to 1800 F.
8. With perhaps a few exceptions all specimens were severely embrittled after exposure. A corresponding decrease in strength properties was apparent, although not measured, and was attributed to the presence of oxygen in solution and possibly internal oxidation.

Acknowledgment

This research was sponsored by the Materials Laboratory, Wright Air Development Center, under Contract No. AF18(600)-60. The research was done in the laboratories of the Department of Mining and Metallurgical Engineering of the University of Kentucky in cooperation with the Kentucky Research Foundation. This paper is based upon part of the dissertation submitted by Hal W. Maynor, Jr., for the degree of Doctor of Engineering, University of Kentucky, Lexington, Ky.

References

1. P. H. Morton and W. M. Baldwin, Jr. The Scaling of Titanium in Air. *Transactions, American Society for Metals*, **44**, 1004, 1952.
2. E. Walden and L. A. Dixon. Properties and Structure of Titanium after Thirty Minutes Heating at 1200 to 2000 F. *Metal Progress*, **88** (1953) Aug.
3. D. J. McPherson and M. G. Fontana. Properties of Melted and Forged Titanium-Chromium Alloys. *Metal Progress*, 366 (1949) Mar.
4. D. J. McPherson and M. G. Fontana. Preparation and Properties of Titanium-Chromium Binary Alloys. *Transactions, American Society for Metals*, **43**, 1098, 1951.
5. G. Welter, A. Choquet, and F. Claisse. Arc Melts of Titanium-Rich Alloys. *Canadian Mining Journal*, **59** (1953) Mar.
6. W. L. Havekotte. Super Refractories for Use in Jet Engines. *Metal Progress*, **67** (1953) Dec.
7. A. E. Jenkins. The Oxidation of Titanium at High Temperatures in an Atmosphere of Pure Oxygen. *Journal of the Institute of Metals*, **82**, Part 5 (1954) Jan.
8. L. W. Eastwood et al. *Summary Report on Preparation and Evaluation of Titanium Alloys*, Part 3, May 18, 1948, to July 30, 1949. Report to Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, by Battelle Memorial Institute, Columbus, Ohio, page 21.
9. C. M. Craighead, O. W. Simmons, and L. W. Eastwood. Titanium Binary Alloys. *Transactions, American Institute of Mining and Metallurgical Engineers*, **188**, 485 (1950) Mar.
10. M. J. Day and G. V. Smith. Iron Alloy Scaling. *Industrial and Engineering Chemistry*, **35**, 1098, 1943.
11. K. Hauffe. The Mechanism of Oxidation of Metals and Alloys at High Temperatures. *Progress in Metal Physics*, New York, Interscience Publishers, Inc.; London, Pergamon Press, Ltd., 1953.

**Any discussions of this article not published above
will appear in the December, 1956 issue.**



Discussions

Preliminary Evaluation of Protective Coating Systems (Topic of the Month) by R. W. Flournoy. *Corrosion*, Vol. 11, No. 7, 289t-290t (1955) July.

Questions by R. B. Kavinoky, Bechtel Corporation, San Francisco, California:

Did electrical resistances measured after one minute, 24 and 48 hours immersion offer as good correlation with the observed durability of the coatings as the resistances measured after several days or weeks immersion? Also, have the studies mentioned been extended to include coatings applied over irregular surfaces such as welds? If so, did such tests result in the elimination of coatings which might have appeared acceptable when examined on smooth steel plates?

Our own experience tends to confirm the merit of the electrical resistance test described, but we suggest that equipment capable of measuring higher resistances at lower voltages might extend the usefulness of the method.

Replies by R. W. Flournoy:

Electrical resistance measurements at one minute, 24, and 48 hours are sufficient to determine whether coatings are poor because of porosity, pinholes, and holidays. Coatings which are relatively free of porosity and holidays require several days or weeks of electrical resistance measurements to show relative values of permeability and moisture absorption.

Tests of coatings over welded and irregular surfaces have been made and add to the value of the test. Coating failures can occur over such irregularities when the same coating is satisfactory on flat surfaces. This is really a problem in surface preparation (grinding, grit blasting) as much as it is a test of coating properties.

The measurement of higher resistance values at lower voltages is a test of increased sensitivity. This fact means that an instrument of greater sensitivity and cost must be used. The use of such instruments can improve this testing procedure whenever the cost is justified.

Principles Applicable to the Oxidation and Corrosion of Metals and Alloys by W. W. Smeltzer. *Corrosion*, Vol. 11, No. 9, 366t-374t (1955) Sept.

Discussion by F. A. Champion, Research Laboratories, British Aluminium Co. Ltd., Gerrards Cross, Bucks, England

Dr. Smeltzer has given an interesting and stimulating

discussion of the laws governing film formation as deduced from theoretical considerations and assumptions. It would be interesting to have his comments on some experimental observations on aluminum in this respect.

Dr. Smeltzer considers (page 370t) that the same laws apply to anodic oxidation in ammonium borate solution as in gaseous oxidation. Experiments have shown that in anodic oxidation the film grows at the metal/oxide interface, while dissolution of the film simultaneously occurs at the oxide/electrolyte interface, although in ammonium borate solution the latter is admittedly very small. My examination (*Trans. Far. Soc.*, 1945, 40, 593) of Steinheil's results (*Ann. Physik*, 1934, 19, 465) indicated that the same law can apply to film formation on a given metal by gaseous oxidation as by wet corrosion, but this (exponential) law was not among those considered by Dr. Smeltzer.

Reply by W. W. Smeltzer:

Dr. Champion's investigation illustrates the complex nature of film formation on aluminum. He has shown that the exponential equation $y = a[1 - \exp(-b(t-c))]$, where y is the total corrosion or the oxide film thickness, t is the time and a , b , c , are constants, satisfies the results over a limited thickness region of film formation during wet corrosion or gaseous oxidation. The results for film formation in pure oxygen at ordinary temperatures are not of sufficient accuracy for quantitative interpretation. If Steinheil's determinations of film thickness in air are assigned the values suggested by Hass,¹ the above equation is applicable from a thickness of 50 Å to the final value of 80 Å.

In aqueous corrosion, Dr. Champion found that the equation was applicable after a relatively large amount of aluminum had been corroded. Whether the same type of film is then formed on the metal in an aqueous environment as in oxygen is open to question. The evidence for this exponential relationship is not very convincing for gaseous oxidation because of its validity over the above thin region of film thickness. On the other hand, Evans,² who reports unpublished work by Hart on the oxidation of aluminum in dry oxygen at ordinary temperatures, states that the inverse logarithmic law is obeyed.

References

1. G. Hass, *Z. anorg. chem.*, **254**, 96 (1947).
2. U. R. Evans, *Revs. Pure Appl. Chem.*, **5**, 1 (1955).

The Porosity of the Aluminum Surface Investigated by the Repetitive Oscillographic Method by W. Machu, E. M. Khairy and M. K. Hus-

sein. Corrosion, Vol. 11, No. 9, 375t-378t (1955) Sept.

Discussion by P. J. Gellings, Laboratory N. V. Werkspoor, Amsterdam, The Netherlands:

In your article there is put forward an equation (in the second column of page 28) to which objections can be raised. This equation is:

$$t_p = B \left(\frac{i_0}{F_0 - F} \right)^{-n}$$

This equation leads to an awkward dimension of B because the exponent n is not an integral number. Also the definition of B₁ (which must have the same dimension as B) as a specific time of passivation with dimension sec/amp/cm² cannot be right.

The main objection to this formula, however, is that B has a variable dimension: Each time a more accurate estimate of n is obtained the dimensions of B must also change in order to conserve the dimensional correctness of the equation.

By writing this equation in the form:

$$t_p = B' \left(\frac{F_0}{i_1} \cdot \frac{i_0}{F_0 - F} \right)^{-n}$$

these objections can be removed. i₁ is an appropriately chosen constant of dimensions amp/cm². The form in brackets is now dimensionless and n has no influence on the dimensions of the new constant B¹.

Reply by W. Machu, E. M. Khairy and M. K. Hussein:

With reference to your remarks we should like to put forth the following arguments in reply:

1. Regarding the dimensions of the constant B as being seconds/amp/cm², it has to be inferred that this constant B as dealt with in the detailed derivation of Müller's equation (Reference 3 in our article) is considered as the specific time of passivation at the current density of one ampere/cm². This means that it is not a function of current but represents a dimension of time at a fixed current density per cm².

To remove this ambiguity, our statement that B amounts to 5.4 sec/amp/cm² (page 28, second column) has to be considered not as a dimensional term but as a term specifying the time of passivation in seconds corresponding to a fixed arbitrary current density of one amp/cm².

2. It seems also that you have been confused by the definitions of F₀ and F stated in this article as representing the total and covered surface area, respectively. In this connection we have to refer again to Müller's equation (1) in which F₀ is considered as unity and hence (F₀ - F) will denote the available active part of this unit surface area. For other values of the total surface than unity, say A₀, Müller's equation (1) will transform into

$$t_p = B \left(\frac{I}{A_0 - A} \right)^{-n} \quad (2),$$

in which I is the initial current strength and A the

inactive part of the surface which is usually covered with a more or less inert surface layer. The term (I/A₀ - A) denotes, of course, the effective current density at a fixed initial current strength I. Equation (2) can be transformed into:

$$t_p = B \left(\frac{i_0}{A_0 (A_0 - A)} \right)^{-n} \quad (3)$$

in which i₀ denotes the initial current density. Virtually equation (3) reduces to

$$t_p = B \left(\frac{i_0}{A_0 - A} \right)^{-n} \quad (4)$$

if A₀ is unity, which is the same form of Müller's equation (1). Therefore (F₀ - F) in our equation denotes the total reactive surface and F represents its inactive part.

It should be noted, however that t_p, which is a function of current density, will have at values of effective current density other than unity the dimension: sec · amp⁻ⁿ · cm²ⁿ, which is a constant dimension for a certain metal under specified conditions.

The equation proposed by you, namely

$$t_p = B' \left(\frac{F_0}{i_1} \cdot \frac{i_0}{F_0 - F} \right)^{-n} \quad (5)$$

seems to be immaterial because each of i₁ and F₀ reduces to unity in view of the above explanation.

Geometric Factors in Electrical Measurements Relating to Corrosion and Its Prevention by W. J. Schwerdtfeger and Irving A. Denison. Corrosion, Vol. 11, No. 10, 423t-432t (1955) Oct.

Discussion by B. Husock, Harco Corporation, Cleveland, Ohio:

I am in agreement with the statement made pertaining to the fact that most of the corrosion occurring on underground pipelines can be attributed to local action and should not be attributed to long line currents. However, the local action pattern described in the article in which the bottom of the pipe is anodic with respect to the top, appears to be a very special case of the local action corrosion activity which usually takes place on bare underground pipelines. While it is true that when there is local corrosion activity on a bare underground pipe, the damage on the bottom of the pipe may be greater than that on the top of the pipe, there is no reason to believe that the bottom is anodic with respect to the top.

In our investigations on bare underground pipe, we have found that when such a pipe is subject to local corrosion activity there is also evidence of pitting and corrosion activity on the top of the pipe, albeit to a lesser degree than that on the bottom of the pipe. Thus, it would appear that the phrase "local action" describes a more localized phenomenon than

that described in the article. It is my opinion that the local anodes and cathodes in the local action corrosion mechanism are very much closer to one another than that indicated in the description given in the article.

Although the conclusions arrived at in regard to the placement of the reference electrodes apply very well to the special case of corrosion on underground pipelines where the bottom is anodic with respect to the top, it appears to me that the article should indicate more clearly that the placement of the electrode is for that special case only. It is my opinion that it is misleading to arrive at more generalized conclusions about half cell locations and work on bare underground pipelines.

Reply by W. J. Schwerdtfeger:

One of the chief motives for giving considerable thought to the positioning of the reference electrode is the fact that some corrosion engineers adhere to the belief that long line currents are responsible for most of the corrosion occurring on pipelines. Consequently during the application of cathodic protection they are content in placing the reference electrode several hundred feet away from the line. In high resistivity soils this procedure can result in inadequate protection.

While the authors have taken the viewpoint that the bottom of a pipeline is generally anodic to the top it is realized that local action, in the strict sense, is simultaneously taking place at the top. In fact, there are also cathodic areas on the bottom. Accordingly, however, on the whole the anodic areas are visualized as occurring on the bottom. Were this not so, the bottom of the line would actually corrode less than the top because of the lesser accessibility of the bottom to oxygen.

I do not agree that the thoughts expressed in the paper apply only as a special case, presumably one where corrosion does not occur on the top of a pipeline, because such a situation probably does not exist. It is felt that the thoughts expressed are rather general, particularly as pertaining to the application of cathodic protection.

Sodium Sulfate in Gas Turbines by Edward L. Simons, George V. Browning and H. A. Liebhafsky. *Corrosion*, Vol. 11, No. 12, 505t-514t (1955) Dec.

Comments by Anton de Sales Brasunas, University of Tennessee, Knoxville, Tennessee:

The authors are to be commended on their excellent treatment of a difficult problem. The writer has been engaged in this field of work and fully appreciates their contribution. Our attempts to induce accelerated attack by mixing sodium sulfate with graphite to achieve reducing conditions have resulted in only slightly increased attack, which became more severe (up to 3X) with high nickel alloys.

An important aspect of the diagram pictured in Figure 6 is the solubility of Na_2SO_4 in CaSO_4 at

913 C. The authors' statement that "5 percent of the ash should be molten" at 913 C presupposes that they know the extent of this solubility. Has this actually been determined? Could not the cohesiveness of the particles be a result of solid phase bonding rather than the presence of a liquid phase? Furthermore, the authors consider the "original ash" as being 97 mol percent CaSO_4 ; can one justifiably neglect the oxides of iron, nickel, chromium, and vanadium, particularly the latter, in making their observations relative to the presence of a liquid phase as a function purely of the calcium and sodium sulfates?

The authors' observations on the autocatalytic destruction is quite interesting and should be carefully studied, particularly with respect to triggering by commonly-encountered conditions. Attempts to induce rapid corrosion by Na_2SO_4 because of reducing conditions was successful in tripling the corrosion rate, but we observed no catastrophic increase as appears to be evident in the authors' work with autocatalytic attack. Furthermore, our attempts to induce increased attack by handling with "sweaty fingers" were entirely unsuccessful in numerous tests. Certainly, if this can induce rapid attack, it must be triggered by a localized condition that is extremely difficult to recognize or reproduce at the present time.

Reply by Edward L. Simons:

Your remarks fall into two categories: Those relating to the physical effects of sodium sulfate and those relating to its chemical effects.

Physical Effects

1. The freezing point-composition diagram shown in Figure 6 was prepared from incomplete literature data which do not indicate the extent of solid solubility of sodium sulfate in calcium sulfate at the eutectic temperature. It is possible, however, on the assumption of zero solubility in the solid state, to calculate a maximum value for the extent of melting of any mixture of the two salts at that temperature regardless of the actual solubility. The 5 percent figure is given in the text (page 507t, right hand column, line 8) as such a maximum.
2. As stated in the text (page 507t) microscopic examination of the ash after heating showed the presence of what had been a molten phase at 925 C.
3. As stated in the text (pages 507t-508t) the oxide constituents of the ash are effectively insoluble in the calcium rich sulfate mixture. It therefore appeared reasonable to consider the melting behavior of the ash as primarily determined by the ratio of calcium to sodium sulfates.

Chemical Effects

1. We have observed what we call autocatalytic attack only when the alloy sample was in contact with a large excess of sodium sulfate. As stated in the text (pages 508t-509t), the attack under these

conditions is sporadic, unpredictable and potentially violent.

2. The nature of the attack which we observed in the crucible tests and the appearance of the salt cake suggested to us that the reaction involved a triggering mechanism, the first step of which was the reduction of sodium sulfate. On the basis of this hypothesis we devised a series of experiments to control the postulated triggering reaction.
3. Under the *reproducible* reducing conditions described in the text we were able to initiate autocatalytic destruction of the alloy samples in the presence of excess sodium sulfate, and to initiate

enhanced oxidation of alloy samples which were coated with only a thin layer of sodium sulfate.

4. On the basis of our hypothesis, it is quite possible that the presence of carbon or "sweaty fingerprints" in the experiments of Reference 6 could serve to trigger the destruction which those authors observed in their crucible tests. However, we do not consider, nor did the authors of Reference 6 find carbon or "sweaty fingerprints" to be reproducible reducing conditions. We can visualize situations in which they would not lead to autocatalytic attack. Were the conditions of your experiments with these agents the same as those described in Reference 6?

Discussions to technical articles appear in the June and December issues only when they do not immediately follow the article to which they pertain. Discussions received from December through May will appear in the June issue and those from June through November in the December issue.



TECHNICAL COMMITTEE ACTIVITIES

A Progress Report by NACE Task Group T-5A-5 on Nitric Acid*

Corrosion by Nitric Acid

Introduction

TASK GROUP T-5A-5 confines its efforts to a study of nitric acid corrosion, specific problems encountered in large scale handling or manufacture of nitric acid and remedial measures employed to eliminate undesirable situations. Prime emphasis is placed upon filling the "gaps" in presently existent nitric acid corrosion data. Surveys are made of industry to determine the type of information most needed. In some instances laboratory tests are made to contribute desired information.

The initial meeting of T-5A-5 was held in Chicago in March 1953. This was primarily an organizational meeting at which specific and immediate objectives for consideration by the committee were prepared.

The second meeting of the committee was held in Kansas City during March 1954. It was decided at this meeting to confine the initial activities and efforts of T-5A-5 to the following phases of nitric acid corrosion:

1. A survey of industries engaged in the large scale consumption of nitric acid in order to determine the need for specific types of corrosion information related to nitric acid problems.
2. A study of corrosion problems encountered in the large-scale production and handling of nitric acid with special emphasis on the use of corrosive measures to mitigate corrosive situations.
3. The procuring and dissemination of information pertaining to nitric acid corrosion and the initiation of laboratory corrosion studies in well established installations to supply or to supplement information on corrosion problems for which there are little or no existing data.

Nitric Acid Questionnaire

To determine the type of information needed the task group has completed a questionnaire that will soon be circulated to producers and consumers of nitric acid. Results of this questionnaire will in large measure determine the future work of the committee.

Nitric Acid Corrosion Bibliography

A bibliography on corrosion by nitric acid has been prepared by the task group. After it has been edited the bibliography will be submitted for publication as a committee technical report.

* James L. English, Oak Ridge National Laboratory, Oak Ridge, Tennessee, chairman.

Abstract

Two cases involving corrosion of nitric acid reboilers are described. In the first case the reboiler had been installed on a 40 to 50 percent nitric acid distillation column. It was found that preferential corrosion attack took place on weld craters which generally contained small hairline cracks. In the second case a nitric acid reboiler used in the purification and concentration of nitric acid failed by corrosion after being in service for a period of nearly one year. The possibility of hexavalent chromium formation during batch-type nitric acid reboiler operation was considered as a possible clue to the cause of failure of the second reboiler.

Air preheater corrosion encountered in the production of nitric acid is considered briefly. Information is given regarding corrosion of welds in equipment used to handle mixed solutions of nitric and sulfuric acid. Other matters discussed include corrosion of aluminum welds in boiling 98 percent nitric acid, cracking of Duriron flanges on pauling towers, vapor-phase corrosion above nitric acid solutions, effect of chlorides on corrosion by nitric acid, and presence of ferrite in austenitic stainless steel welds.

Reports are given of explosions occurring when titanium test specimens were used in conjunction with red fuming nitric acid. It is not definitely known just what causes such explosions, nor are there any well developed theories on the mechanism by which they occur. The use of zirconium in nitric acid solutions is described briefly.

Corrosion Problems in Nitric Acid Production

A project group of T-5A-5 has submitted the following reports on corrosion problems in the production of nitric acid.

Corrosion of Nitric Acid Reboilers

Case 1. A reboiler was installed on a 40 to 50 percent nitric acid distillation column. The reboiler was operated at a temperature of approximately 275 F. Steam was passed through the reboiler tubes and nitric acid contacted the outer surfaces of the tubes. The reboiler contained an AISI Type 347 stainless steel tube sheet. Other stainless steels in the reboiler were AISI Types 309SCb and 347. The tubes were fabricated using 180 degree return bends. Preferential corrosion attack took place on weld craters which generally contained small hair line cracks. No chipping, grinding, nor back-welding was used during fabrication to remove the hair line shrinkage cracks from the weld craters.

AISI Type 304L stainless steel tubes welded with AISI Type 308L rod were found to be superior in corrosion resistance to the Type 347 stainless steel welded tubes. All welding was conducted

with the inert gas-shielded arc process. No crater-cracking was observed when the Type 308L weld rod was used in welding 304L stainless steel.

It has not been fully established whether the crater corrosion attack was caused by the presence of low-melting constituents formed during the welding operation or by the development of crevices arising from shrinkage effects.

The project group directs attention to the work of Fontana and Beck at Ohio State University which indicates that AISI Type 304L stainless steel is more corrosion-resistant to nitric acid solutions at temperatures in excess of 220 F than Type 347 stainless steel.

Case 2. A nitric acid reboiler used in the purification and concentration of nitric acid failed by corrosion after being in service for a period of nearly one year. The reboiler was AISI Type 347 stainless steel fabricated into a vessel about three feet in diameter. The vessel was exposed during intermittent operation to an 11 M nitric acid solution at 300 F during the course of the year. Actual time in operation was estimated to be around six months. The solution entering the reboiler was between 6 and 7 M in nitric acid concentration; this solution was then concentrated to about 11 M in nitric acid concentration. The purity of the entering nitric acid was very high because it was the end product of a purification process.

Chemical analysis on the entering solution showed that the chloride content was almost negligible. After failure had occurred, various components of the reboiler were carefully examined. Severe edge corrosion was found on the spacer bars used to support the steam-heating coils in the vessel. A similar type of attack was observed on the end of the fill tube. The butt-welded areas on the steam coils exhibited a very severe localized type of corrosion attack.

The immediate cause for the failure of the reboiler was not apparent. Chemical analyses of the material

TABLE 1—The Effect of Chromium (VI) Additions to 7 M Nitric Acid On the Corrosion of Type 309SCB Stainless Steel

Total Time (Hours)	Temperature (Degrees C)	Initial Chromium Concn (gm/liter)	Corrosion (mils/year)
50 100 500 1000 2500	66	0	0.2 0.2 0.1 0.1 0.1
50 100 500 1000 2500	66	2.5 Cr(VI)	70 103 116 82 34
50 100 500 1000 2500	110	0	1.5 1.7 1.3 1.2 1.4
50 100 500 1000 2500	110	1.0 Cr(VI)	382 320 94 65 54
50 100 500 1000 2500	110	1.0 Cr(III)	1.4 4.8 6.2 11.0 15.0

which had shown excessive corrosion attack disclosed that the materials were within the chemical compositions limits for AISI Type 347 stainless steel.

Reference is made to an article by J. E. Truman and H. T. Shirley which appeared in the *Journal of the Iron and Steel Institute* (Vol. 171, August 1952, pp 354-358). The article concerned the accelerating effect of hexavalent chromium on the corrosion of austenitic stainless steels by nitric acid solutions. It was stated in the paper that the ability of nitric acid solutions to oxidize chromium metal in the stainless steels to the hexavalent state was related, among other factors, to the nitric acid concentration and to the temperature of the nitric acid solution. The possibility of hexavalent chromium formation during batch-type nitric acid reboiler operation was considered as a possible clue to the cause for failure of the reboiler.

Corrosion studies have been conducted at the Oak Ridge National Laboratory on the effect of hexavalent chromium as an accelerator of corrosion attack on austenitic stainless steels by nitric acid solutions. A condensed resume of the results of these studies is presented in Table 1.

The accelerating effect of hexavalent chromium on the corrosion of Type 309SCB stainless steel by a boiling and air-aerated 7 M nitric acid solution is clearly illustrated by the data in Table 1. In addition to a very severe generalized acid-etch type of attack on flat portions of sheet-type specimens, an extremely localized corrosion attack took place on the edges of sheet specimens. In boiling solutions of similar total nitrate concentration, this type of attack was so pronounced that wafer specimens, machined from Type 309SCB stainless steel bar, were completely penetrated after an exposure period between 3000 and 4000 hours. The depth of the penetration was 250 mils. The type of corrosion attack observed on the laboratory corrosion specimens was markedly similar to the nature of the edge corrosion found on the components which failed in the nitric acid reboiler described under Case 2.

Thus far, it has been found that the only satisfactory method for minimizing or eliminating the hexavalent chromium effect on the austenitic stainless steels exposed in nitric acid solutions was to reduce the temperature of the test solutions to a level where the oxidizing capacity of the nitric acid solution employed in the tests was not sufficient to promote the formation of hexavalent chromium. Studies are being continued with boiling nitric acid solutions and are concerned with the addition of various chemical reagents which will either reduce or precipitate the hexavalent chromium formed during the operation of the particular test.

An item of interest in the data contained in Table I is that a boiling and air-aerated solution of 7 M nitric acid has sufficient oxidizing capacity to oxidize trivalent chromium additions to the hexavalent chromium state and thereby cause an acceleration in the rate of corrosion attack on Type 309SCB stainless steel.

Air Preheater Corrosion

In the production of nitric acid, an air preheater was connected directly to the platinum gauze catalyst converter wherein air and ammonia were reacted to produce gaseous oxides of nitrogen. Process air containing oil vapors (presumably from a reciprocating compressor) circulated through the shell side of the exchanger while the gaseous oxides of nitrogen passed through the tubes at a temperature between 1600 and 1700 F. As a result of the passage of the oil-contaminated air over the outside of the tubes, the outer surfaces of the tubes eventually became carburized. The tubes in the heat exchanger were Type 347 stainless steel. The heat exchanger tubes subsequently were embrittled and cracking was suspected to have been caused by the generation of high thermal stress arising from the thermal expansion and contraction of the tube sheet during operation and shut-down periods.

The tube life was extended by the simple expedient of eliminating the oil-vapor contamination from the air stream by means of an oil filter. Beneficial effects were realized by coating the hot portions of the tube sheet with a refractory-type cement.

Corrosion of Welds in Equipment Used to Handle Mixed Solutions of Nitric and Sulfuric Acids

Submerged arc welds in carbon steel equipment for handling mixed nitric-sulfuric acid solutions underwent severe preferential corrosion attack. The acid solution contained 85 percent nitric acid and 12 percent sulfuric acid. Manual metallic-arc welds were found to be more corrosion resistant in the environment. Stress relieving the welded equipment also improved the corrosion resistance of the weldments.

Pauling Towers

Duriron used for towers handling 68 percent sulfuric acid containing small amounts of nitric acid was found to crack through the support flanges and the walls. The towers operated at temperatures in the vicinity of 360 F. Cracking was generally the result of poor and improper design rather than the result of any specific and selective corrosion attack. The use of ample structural steel supports to retain alignment and proper bolt tension in the flanges eliminated the cracking susceptibility of the alloy.

Aluminum

Welds in aluminum pipe have been found to corrode rapidly in boiling 98 percent nitric acid. In a case reported, the pipe was 61S aluminum alloy, welded with 43S aluminum alloy weld rod. Heliarc welds corroded to a lesser extent but the rate remained excessive. When 3S aluminum pipe was used with 2S aluminum welds, the corrosion attack on the welds was drastically reduced. This problem is currently under study by the task group.

Red Fuming Nitric Acid

Two incidents were reported involving explosions of corrosion test specimens of 4 percent manganese-

titanium and 7 percent manganese-titanium alloys in red fuming nitric acid at room temperature and atmospheric pressure. In each case there was an eruption of part of the contents of a flask in which the test was being conducted. They also involved arcing, over a distance of some inches, of an electrical charge from the specimen to the ground. The explosion was accompanied by a detonation described as comparable to that produced by a two-inch firecracker. It was reported that while the arc had been fairly short, it was considered it could easily have jumped several feet.

Another company reported two room-temperature, atmospheric-pressure explosions in red fuming nitric acid. In these instances there had actually been a splattering of molten titanium from the surfaces of the specimens.

An incident occurred at the Bureau of Mines Station at College Park, Maryland, in which 24 flasks containing five specimens each were in their fourth day of exposure to red fuming nitric acid at room temperature and atmospheric pressure. Each flask contained about a half liter of acid. A man in the laboratory approached the flasks and supposedly moved one of them. The entire group of flasks then detonated simultaneously. The man was seriously injured. It was expected that he would be hospitalized for a year and that he would be partially to completely blinded. Another man rushed into the laboratory to help the injured man. The second man was overcome by the fumes and died four days later from pneumonia. A person in an adjacent laboratory room reported a loud cracking noise but did not remember a flash of light. Splattering of molten metal occurred from some specimens as determined by a later examination. The laboratory had been making such tests for six years.

Another research laboratory reported two incidents involving exposures of titanium-aluminum couples in fuming nitric acid. These metals were attached by a nichrome wire. When the wire was unbolted from the titanium, there was an electric discharge to the ground with an accompanying flash of light.

Two other laboratories reported incidents that occurred during the testing of titanium in 65 percent boiling nitric acid. At the end of the first 48 hour period when the flask was moved, a minor explosion occurred. Part of the contents of the flask erupted.

One company reported that with 20-22 percent nitric oxide and sufficient heat, an explosion will be produced spontaneously. They believe a combination of four conditions can cause detonation: 1. Impact, 2. Heat, 3. Manganese content, and 4. Corrosion products. They expressed the opinion that with commercially-pure titanium the explosions would not occur. This has not been borne out however by other experiences. The Bureau of Mines experience occurred in alloy RC-55, which is commercially-pure titanium with only 0.02 to 0.07 percent manganese.

Some persons believe that eruptions from the metal have occurred only from areas which were severely attacked by corrosion. A properly-annealed titanium surface has almost complete resistance to fuming nitric acid. Severely-cold worked or other-

wise highly stressed surfaces appear to be more or less readily attacked by red fuming nitric acid. An examination of many of the specimens which had been exposed revealed evidence of burning at sheared edges and other cold worked areas. Where severe sharing of the edge has occurred, resulting in splintering, the edge takes on the appearance of burning in a short-time exposure. Specimens with carefully prepared smooth edges and vacuum-annealed at 1000 C have shown far superior corrosion resistance.

Some persons do not think long-time exposure is necessary. The rapid attack is considered more a function of a highly vulnerable local area and is not thought to be a result of continuing attack. Most experiences which resulted in explosions occurred within a few days from the start of the test.

It is not definitely known just what causes such explosions, nor are there any well developed theories on the mechanism by which they occur. Conclusions drawn are that all persons working with titanium in nitric acid should observe extreme caution. All work should be done under a hood with a shield between the worker and the flask. The worker should wear styrene gloves, a mask, and protective clothing. Any other precautions which would serve to protect the worker should be observed.

The remote possibility that such attack could occur in a system such as CA-66 was considered. As it is felt to be firmly established that the phenomenon occurs only in an alloy consisting almost entirely of titanium, there is no evidence to suggest any such hazard in exposure to the stainless steels. In addition, a large number of corrosion tests have been performed without incident.

Precautions should be taken regarding couples. There is evidence to indicate that materials which in themselves have considerable resistance can be corroded when anodic to a more noble metal. It also has been observed that when stainless steel was coupled with titanium in an exposure to 0.1 normal sulfuric acid, the corrosion rate for titanium was much higher than for the titanium alone. It is believed that the hydrogen evolved from the stainless steel partially destroys the oxide film on the titanium, reducing its corrosion resistance.

It also has been reported to the committee that zirconium will explode under certain conditions when in contact with nitric acid solutions. The explosions can be eliminated from a zirconium-nitric acid system by the addition of hydrofluoric acid to the nitric acid solution.

Ferrite in Austenitic Stainless Steel Welds

It has been reported to the committee that about 5 percent free ferrite is required to prevent cracking in AISI Type 347 stainless steel welds. There does not appear to be much information in the published literature on the corrosion resistance of ferrite-containing weldments.

Bloom and Carruthers report in the ASTM Symposium on Evaluation Tests for Stainless Steels, Special Technical Publication No. 93, that delta ferrite pools present in Type 347 stainless steel weldments did not exhibit any preferential corrosion attack in copper sulfate-sulfuric acid solution nor in nitric acid-hydrofluoric acid solution.

Studies at Oak Ridge National Laboratory with heliarc weldments of Type 347 stainless steel containing 3, 5 and 8 percent free ferrite in the welds indicated that there was no decrease in the corrosion resistance of the weldments as the ferrite content was increased. The corrosion tests were run in boiling 65 percent nitric acid solution.

Committee discussions on the relative merits of AISI Types 304L, 321, 347 and 430 stainless steels resulted in the conclusion that Type 304L stainless steel welded with Type 308L weld rod is the most satisfactory combination for nitric acid service at temperatures below 800 F.

Vapor-Phase Corrosion Above Nitric Acid Solutions

Work has been reported on a vapor-phase corrosion problem involving a solution containing 40 percent nitric acid and 1 percent sulfuric acid at an operating temperature between 110 and 165 C. Corrosion test results with AISI Types 304L, 309SCb and 347 stainless steels were erratic. The specimens exhibited channeling and grooving. The liquid-phase corrosion was quite severe with corrosion rates of approximately 50 mils per year.

Effect of Chlorides on Corrosion by Nitric Acid

The question has been asked whether or not chloride impurities in a nitric acid fractionation column were concentrated in the column during operation. If such concentration did occur, what was the resulting effect on the corrosion of weirs, risers, bubble caps and trays? Committee members reported they were operating a fractionation column satisfactorily by maintaining the chloride level between 300 and 500 ppm. They also reported that fluorides were of greater concern than chlorides and that it was necessary to control the fluoride level at concentrations less than 50 ppm to prevent excessive attack on the stainless steel equipment.

Status Report of NACE Technical Unit Committee T-1J On Oil Field Structural Plastics*

Introduction

THIS REPORT summarizes the activities of Technical Unit Committee T-1J on Oil Field Structural Plastics from October 1955 through March 1956. This and other status reports along with T-1J reports published in the Technical Section are designed to keep NACE members up-to-date on the activities and findings of the committee.

Part 1. Laboratory Testing of Glass Plastic Laminates⁽¹⁾

Edgewise Porosity Test

Pipe fabricated from resins reinforced with continuous glass fibers show remarkable strength. Short-term tests indicate the resistance to failure by bursting rivals that of steel. More detailed examination and testing reveals weaknesses which appear to be typical of this type of construction in its present stage of development.

The tendency of the material to creep under load and accelerating influence of water and increased temperature on creep rate have been reported previously. Another weakness found in mandrel wound glass-plastic pipe is its tendency to develop slow weeping type leaks at pressures far below those which ordinarily would cause failure by rupture. The nature of these leaks led to the thought that they might occur because of poor glass-resin bond. To test this theory and to supplement direct microscopic examination by a more positive method of measuring bonding improvement, edgewise porosity tests for pipe and flat laminates were devised.

Figure 1 shows a test unit which provides a double rubber packing gland around the end of a test section of pipe so that fluid pressure can be applied to the end edge alone. The pipe surface is visible for inspection while liquid pressures to 1000 psi or more can be applied to the end edge of pipe sections. With a given pipe size only the spacer tube need be changed for different length test sections.

Figure 2 shows an analogous unit for applying edge pressure to flat laminates. The characteristics of flat laminates are of interest principally because many factors involved in glass-plastic construction can be studied in the initial stages of fabrication of flat laminates more conveniently than in

Abstract

Mandrel wound glass-plastic pipe has a tendency to develop slow weeping type leaks at pressures far below those which ordinarily would cause failure by rupture. It was thought that poor glass-resin bond might be responsible for such leaks. To test this theory and to supplement direct microscopic examination by a more positive method of measuring bonding improvement, edgewise porosity tests for pipe and flat laminates were devised. An account is given of the procedure followed in making these tests and of the results obtained.

Circumferential measurements were made to determine creep on a 250 barrel glass mat reinforced polyester oil field stock tank. A comparison of empty and full measurements during the second and third summers showed little difference. Similar measurements were made on a 250 barrel glass fiber reinforced epoxy oil field stock tank. It was found that less circumference difference occurred between the second summer and winter than during the first year. Summer measurements will be made until such time as no more creep is indicated.

Results of high pressure field tests on glass reinforced plastic pipe and tubing are reported in detail.

pipe fabrication. The unit shown in Figure 2 was used to apply pressures to 1000 psi to the inside edge of annular discs cut from flat laminates. Three-inch diameter discs with one-inch diameter centered holes were used in tests. These discs were cut from laminates approximately three-sixteenths inch thick. A wide range of specimen thicknesses and diameters could have been used without alteration of the fixture because the center hole was the only fixed specimen dimension.

Leakage from pipe sections was usually in the

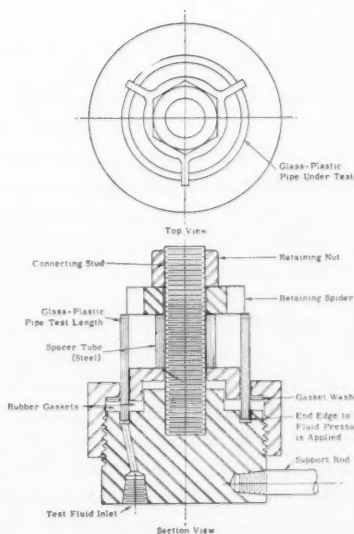


Figure 1—Glass-plastic pipe axial porosity test unit.

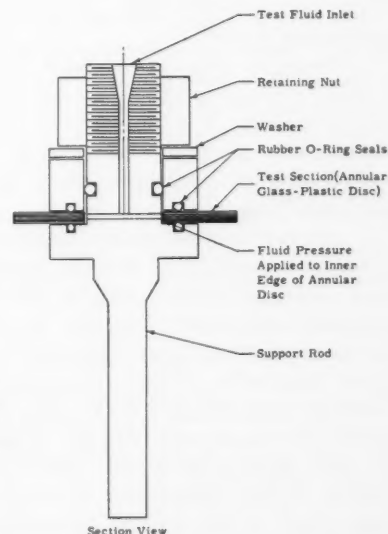


Figure 2—Glass-plastic flat laminate edge porosity test unit.

* E. W. Bradley, Shell Oil Company, New York, N. Y., chairman.

(1) A contribution to NACE Technical Unit Committee T-1J, by W. H. Sharp, Shell Development Co., Emeryville, Calif.



Figure 3—Continuous fiber pipe section after porosity test. Helically wrapped resin-glass yarn pipe after one-inch long section was subjected to 100 psi water pressure for 24 hours. Approximately 450 tiny white spots visible on end edge (by microscopic examination) resulted from deposits left by evaporation of tiny droplets of dilute salt solution.

TABLE 1—Properties and Operating Conditions of Glass-Polyester Tank

TIME	Atmospheric Temperature in Degrees F at Strapping Time	
	Tank Full	Tank Empty
First Winter 1/53.....	92	72
First Summer 9/53.....	41	—1
Second Winter 1/54.....	89	97
Second Summer 7/54.....	22	26
Third Winter 1/55.....	81	79

Resin: Polyester

Glass Fibers: Stave—3 layers of 3 ounce per square foot glass mat.
Bolt Line—4 layers of 3 ounce per square foot glass mat

Tank Dimensions: Height—8 feet.
Diameter—15.5 feet.
Stave Wall Thickness—0.15 inches.
Stave Bolt Line Thickness—0.20 inches.

Service: Oil Stock Tank.

Calculated wall stress 12 inches off bottom assuming full tank of 35 degree API oil with no reinforcing by the bottom according to Barlow's formula: 1590 psi.

form of tiny droplets of water on the top edge. Water used contained a trace of salt to facilitate detection of leaks. The number of droplets varied unpredictably from a few to several hundred in number depending on quality of sample, length of path, pressure and time under pressure. They were normally scattered erratically over the top edge surface of helically wrapped pipe (Figure 3). On the other hand, pipe with straight axial fiber layers showed most leakage through these layers which were the shortest leakage paths. Similar effects were observed in tests of flat laminates constructed from square weave cloth. Application of water pressure to the inner edge of the annulus invariably produced leaks to the outer edges which were along the path of fibers from the inner edge (Figure 4).



Figure 4—Glass-plastic laminate edgewise porosity specimen. Glass cloth-resin laminate after application of 100 psi water pressure to inner edge for two days. White spots in foreground are one of four such groups spaced at 90 degrees around circumference. They are salt residue from tiny droplets which began to appear within an hour after application of pressure.

TABLE 2—Properties and Operating Conditions of Glass-Epoxy Tank

TIME	Atmospheric Temperature in Degrees F at Strapping Time	
	Tank Full	Tank Empty
First Winter 1/54.....	31	44
First Summer 7/54.....	85	104
Second Winter 1/55.....	22	29
Second Summer 7/55.....	79	76

Resin: Epoxy.

Glass Fibers: Two horizontal layers glass roving.
One vertical layer glass roving.
11 ounces per square foot glass in stave.
16 ounces per square foot glass in bolt line.

Tank Dimensions: Height—8 feet.
Diameter—15.5 feet.
Stave Wall Thickness—0.125 inch.
Stave Bolt Line Thickness—0.250 inch.

Service: Oil Stock Tank.

Calculated wall stress 12 inches off bottom assuming full tank of 35 degree API oil with no reinforcing by the bottom according to Barlow's formula: 1910 psi.

High pressure increased the rate of appearance of axial leaks but was not a necessary condition for their production. Short tube sections (1 to 2 inches) under as little as 50 psi water pressure often showed almost immediate leakage to the other end. Continued application of pressure over periods of a month caused continued increase in the number of leaks although rates were very low. Five-hundred to 1000 psi was necessary to produce immediate axial leakage in six-inch long test sections. In many cases longer sections showed break-through of axial leaks to the inner or outer wall surfaces.

Correlation of axial porosity with internal pressure leaks was further indicated by the following experiment. Several six-inch lengths of pipe, which had developed weeping type leaks under internal pressure, were subjected to 1000 psi pressure at an end edge only. In each case the areas which leaked under internal pressure also leaked from end pressure alone, indicating that the exposed end edges of glass-

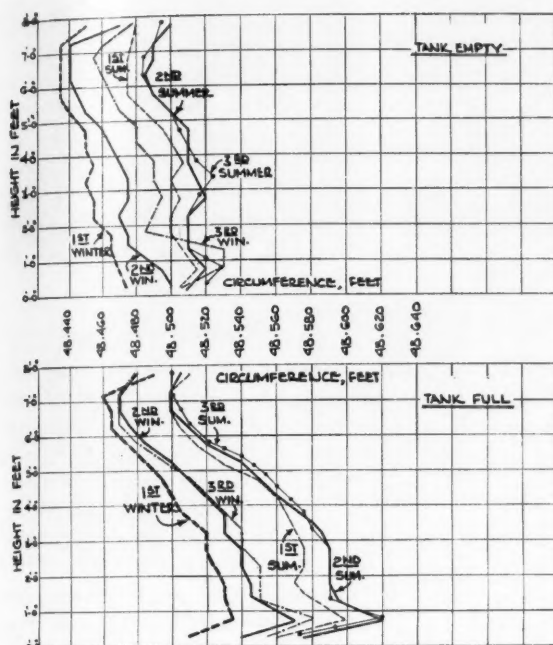


Figure 5—Circumferential measurements of glass-polyester stock tank.

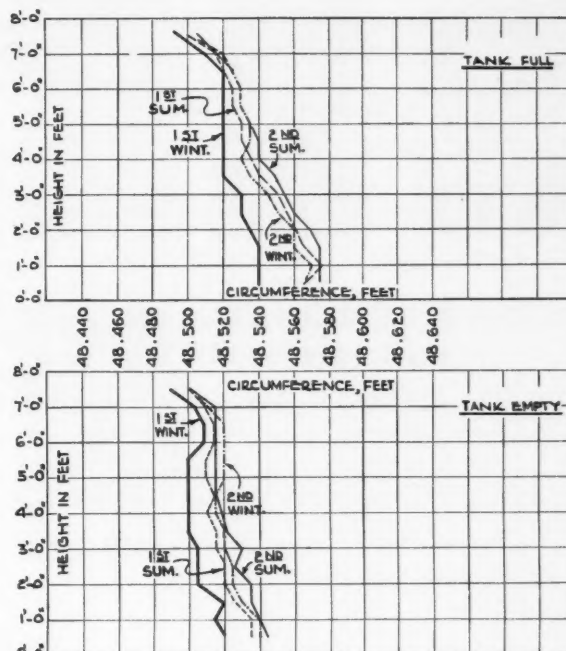


Figure 6—Circumferential measurements of glass-epoxy tank.

plastic pipe were a likely starting point for internal pressure leaks.

Part 2.

Service Experience of Glass-Reinforced Plastic Tanks

This report supplements reports on service experience of plastic tanks included in Status Reports of T-1J published in the Technical Committee Activities Section of the June 1955 and March 1956 issues of *Corrosion*. The curves in Figures 5 and 6 correspond to Figures 1 and 2 respectively in the March 1956 report.

Glass-Polyester Tank

Figure 5 shows the circumferential measurements of a 250 barrel glass mat reinforced polyester oil field stock tank, both empty and full, during three winters and summers. A comparison of empty and full measurements during the second and third summers shows little difference. The operator be-

TABLE 3—Summary of High Pressure Field Tests of Glass-Reinforced Plastic Pipe¹

Test No.	Installation Date	Length of Test Section	Operating Pressure	Operating Temperature in Degrees F	Remarks
1	8-31-54	3 Foot Section	520 psi	100	Salt water injection line.
2	10-11-54	3 Foot Section	.....	...	Laboratory test.
3	11- 1-54	8 Foot Section	100 psi	100	Salt water flush line on a ship.
4	11- 1-54	3 Foot Section	1080 psi	83	Salt water injection line.
5	11- 8-54	3 Foot Section	1050 psi	75	Brine water injection line.
6	11- 9-54	17 Foot Section (.19 Inch Wall)	5 psi	130	Process piping ammonium sulfate solution. 5-10 percent free sulfuric acid.
7	11-12-54	3 Foot Section	900 psi	80	Brine water injection line.
8	11-16-54	3 Foot Section	520 psi	100	Salt water injection line.
9	11-16-54	7 Foot Section	71 psi	100	Gathering line, sour crude and brine. Steel line completely closed from paraffin deposition in fifth month. Fibercast showed no paraffin deposition 2-56.
10	12- 2-54	3 Foot Section	550 psi	100	Pipe installed in brine injection line 575 ppm H ₂ S.
11	7- 6-55	28 Foot Section (.19 Inch Wall)	550 psi	100	Salt water injection line.
12	11-28-55	30 Foot Section (.19 Inch Wall)	200 psi	100	Flow line to test sour crude and paraffin deposition.
13	12- 5-55	45 Foot Section (.19 Inch Wall)	550 psi	120	Salt water injection line.
14	12-14-55	26 Foot Section (.26 Inch Wall)	900 psi	100	Salt water injection line.
15	2- 8-56	26 Foot Section (.19 Inch Wall)	15 Inch Mercury Vacuum	150	Feed line to vacuum cooler 29 percent phosphoric acid.
16	2- 8-56	8 Foot Section (.19 Inch Wall)	55 psi	200	Discharge line on a digester circulating pump. Twenty-nine percent phosphoric acid in 40 percent slurry.
17	2- 8-56	6 Foot Section (.19 Inch Wall)	55 psi	260	Discharge line on 75 percent phosphoric acid pump.

¹ Pipe Size: 3 1/4-inch outside diameter, 0.33-inch wall except as noted.
Resin: Epoxy
Service: Line pipe

TABLE 4—Summary of High Pressure Field Tests of Glass-Reinforced Plastic Tubing¹

Test No.	Installation Date	Length of Test Section	Operating Pressure	Operating Collapse Pressure	Tensile Load in Pounds	Operating Temperature in Degrees F	Remarks
1	7-21-55	3460 Feet	28 Inch Mercury Vacuum	217 psi	4508	100	Tubing use in a salt water disposal well.
2	8-17-55	3400 Feet	28 Inch Mercury Vacuum	205 psi	4263	100	Tubing use in a salt water disposal well.
3	11- 1-55	3600 Feet	28 Inch Mercury Vacuum	256 psi	4669	100	Tubing use in a salt water disposal well.
4	11-22-55	.....	28 Inch Mercury Vacuum	367 psi	4971	100	Tubing use in a salt water disposal well. Disposal input rate of water is 400 barrels/hour. Same size cement line steel tubing could not handle this input rate.
5	11-30-55	2813 Feet	70 psi	None	5110	100	Tubing use in a chemical input well 471 barrels/hour input of salt water + 200 gal 35 percent HCl.
6	12- 9-55	2567 Feet	Vacuum	211 psi	3125	100	Tubing use in salt water disposal well.
7	1- 9-56	400 Feet	341 psi	None	3110	100	Tubing run in a water supply well A 933 pound Reda Pump and cable is hung on the bottom of the tubing. Pump produces 150 foot pounds torque when starting.

¹ Pipe Size: 3 1/4 inch outside diameter, 0.26-inch wall.
Resin: Epoxy
Service: Tubing

TABLE 5—Summary of High Pressure Field Tests of Glass-Reinforced Plastic Pipe¹

Test No.	Installation Date	Length in Feet of Test Section ¹	Operating Pressure in psi	Remarks
1	6- 6-55	40	600	Corrosion control in buried salt water service.
2	6- 8-55	20	1,000	Corrosion control in buried salt water service.
3	6- 8-55	20	600	Corrosion control in buried salt water service.
4	6-10-55	20	0-250	Corrosion control in surface sweet crude service. Wellhead pressure fluctuates between 0 and 250 psi, with each stroke of the pump which is set at 20 strokes per minute. "3M" pipe has withstood over 5-million pressure pulsations to date. There is also pronounced mechanical vibration in this line which is absorbed by the test section.
5	6-20-10-28-55	40	600	Corrosion control in buried salt water service. This installation was moved from the original location and put into the new service on 10-28-55.
6	10-28-55	40	800	Corrosion control in buried chlorinated fresh water and salt water service. This installation was moved from the original location and put into the new service on 10-28-55.
7	6-21-55	20	550	Corrosion control in buried salt water service. ²
8	6-21-55	20	550	Corrosion control in surface salt water service.
9	6-23-55	30	1,100	Corrosion control in surface salt water service.
10	7-13-55	30	....	Corrosion control in buried salt water service.
11	7-14-55	10	....	Vent line for corrosion control.
12	4- 8-55	40	30	Paraffin control in surface sweet crude service. "3M" pipe successfully withstood hot oiling at 175 F for several hours to remove paraffin from the entire flow line.
13	6-22-55	40	45	Paraffin control in surface sweet crude service. ³
14	7-11-55	30	30	Paraffin control in buried sweet crude service.

¹ Ten-foot joints of two-inch threaded and coupled pipe have been used for all initial tests in order to utilize more "3M" couplings (20-foot joints are now also available.)

² One joint was damaged by shifting backfill and was removed. The operator agreed that the difficulty lay in the connection to steel pipe. Surface installation in the same line continues to perform satisfactorily.

³ Inspection after over three-months' service showed a slight accumulation of paraffin. After nearly six-months' service there was enough paraffin in the entire flow line to require hot oil treatment. "3M" Pipe was removed for laboratory examination of the deposition which had occurred in it. This pipe has not yet arrived in St. Paul for inspection.

¹ Pipe Size: 2.25-inch outside diameter, wall thickness 0.09 inch
Service: Line pipe

believes very little, if any, creep will continue and for that reason has discontinued measurements on the tank. The operator is satisfied with the performance of the tanks and believes they are suitable as standard oil field items.

A summary of the tank properties and operating conditions are given in Table 1.

Glass-Epoxy Tank

Figure 6 shows similar measurements on a 250 barrel glass fiber reinforced epoxy oil field stock tank. In both empty and full conditions it can be seen that less circumference difference occurred between the second summer and winter than during the first year. A comparison of summer measurements indicated continued creep inasmuch as temperature effects are at a minimum by this comparison. The operator plans to discontinue winter measurements because it is difficult to secure common winter temperatures. Summer measurements, on the other hand, are easily available in the 80-90 F range. Summer measurements are to be continued until no more creep is indicated. A summary of tank properties and operating conditions are given in Table 2.

Part 3.

High Pressure Field Tests of Glass-Reinforced Plastic Pipe

H. S. Boggs of the Fibercast Corporation and Ward B. Sanford of Minnesota Mining and Manufacturing Company have presented reports on high pressure field tests on pipe manufactured by their companies. Details of Mr. Boggs' report are contained in Tables 3 and 4. Details of Mr. Sanford's report are contained in Table 5.



Dial



Gackebach



Koger



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Parker



Roebuck



Rutherford



Simmons



Skinner

Many Technical Committees Elect New Officers to Serve Two Year Terms

Many technical committees have elected new officers to serve for the next two years. Some elected include:

- T-1D R. E. Lembcke, Cities Research & Development Co., Tulsa, Oklahoma, chairman; J. V. Gannon, The Texas Co., Midland, Texas, vice-chairman.
- T-1F Monte Kaplan, Atlantic Refining Co., Dallas, Texas, chairman; H. M. Cooley, Bethlehem Steel Co., Tulsa, Okla., vice-chairman.
- T-1G Monte Kaplan, Atlantic Refining Co., Dallas, Texas, chairman; J. J. B. Rutherford, Tubular Products Div., The Babcock & Wilcox Co., Beaver Falls, Pa., vice-chairman.
- T-1H W. C. Koger, Cities Service Oil Co., Bartlesville, Oklahoma, chairman.
- T-1K A. H. Roebuck, Continental Oil Co., Ponca City, Oklahoma, chairman; E. J. Simmons, Sun Oil Co., Dallas, Texas, vice-chairman.
- T-2D M. E. Parker, Comit Engineering Co., Houston, Texas, chairman.
- T-4A T. R. Stille, Good-All Electric Mfg. Co., Ogallala, Nebraska, chairman.
- T-4D D. W. Kaufmann, International Salt Co., Inc., Buffalo, New York, chairman; W. H. Bruckner, University of Illinois, Urbana, vice-chairman.
- T-5B E. N. Skinner, The International Nickel Co., Inc., New York, N. Y., chairman; J. L. McPherson, Blaw Knox Co., Pittsburgh, Pa., vice-chairman.
- T-5D S. W. McIlrath, Euclid, Ohio, chairman; R. E. Gackebach, American Cyanamid Co., Bound Brook, N. J., vice-chairman.
- T-6B H. C. Dick, Products Research Service, Inc., New Orleans, La., chairman; R. S. Freeman, Cities Service Refining Co., Lake Charles, La., vice-chairman.
- T-6E F. T. Rice, Pure Oil Co., Chicago, Illinois, chairman; D. F. Dial, Jr., Pure Oil Co., Houston, Texas, vice-chairman.

COMMITTEES INVITED TO THESE MEETINGS

Northeast Region: October 15-17, 1956, Drake Hotel, Philadelphia, October 15 reserved for technical committee meetings. To reserve meeting space notify T. J. Hull, NACE, 1061 M & M Bldg., Houston.

South Central Region: October 23-26, 1956, Gunter Hotel, San Antonio, Texas, October 23-24 reserved for technical committee meetings. To reserve meeting space notify T. J. Hull, NACE, 1061 M & M Bldg., Houston.

North Central Region: November 15-16, 1956, Detroit. To reserve meeting space notify T. J. Hull, NACE, 1061 M & M Bldg., Houston.

Batch Treatment of Oil Wells Being Tested by Several Companies

It has been reported to Unit Committee T-1H on Oil String Casing Corrosion that several companies are injecting anhydrous ammonia into the casing-tubing annulus in 25-pound batches at quarterly intervals. Other companies are treating with 50-pound batch treatments annually. Although results are reported to have been inconclusive to date, recent caliper surveys indicated no increase in corrosion during the interval between treatments.

Volatile and filming-type inhibitors also have been discussed at length. The use of filming-type inhibitors is widely practiced in the West Texas-New Mexico area and it was reported that one company batch treats casing-tubing

(Continued on Page 74)

Tank Car Task Group Discusses Caustic Soda, Epoxy Coatings

The New York meeting of Task Group T-3E-1 on Corrosion of Railroad Tank Cars was attended by more than 50 members and guests. Discussions at the meeting exemplified the interest and activity by members of the committee including:

Experience in Shipping Caustic Soda

Results obtained from T-3E-1 field data sheets during the first year of the committee's activity were discussed. Three shippers of 73 percent caustic soda reported at that time that they used a Neoprene latex coating on tank cars. One shipper reported he obtained from 20 to 30 trips from a tank car coated with the material. Another shipper considered the coating satisfactory but did not indicate the number of trips obtained. The third shipper indicated a longer service life was desired. It was pointed out that most of the failures could be attributed to the failure of the adhesive primer.

The difficulty is recognized by suppliers and attempts are being made to improve the quality of the primer. Most shippers were of the opinion that there is no precise definition of failure, but a lining was considered to have failed when the customer complained. It was pointed out that the practice of washing cars after each trip is hard on coatings, but could not be avoided. It is difficult to repair Neoprene type coatings. Careful feather-edging around failed areas is required. Coating thicknesses are on the order of 20 to 25 mils.

It was reported that epoxy base coatings of approximately 5 mil thicknesses are being used for 73 percent caustic service but no precise information has yet been made available to the committee.

Epoxy Base Coatings

It was reported to the committee that propylene glycol has been shipped for two years in a car lined with an epoxy coating of 6 to 8 mils.

A catalyst-cured epoxy coating of 6 mils thickness failed to resist glacial acetic acid in a laboratory test. It has not been tried on a tank car.

A baked epoxy of 6 to 8 mils thickness is giving satisfactory service in carbon tetrachloride shipment. Length of service was not reported.

Natural and synthetic latex emulsions have been shipped for more than three years in cars lined with a baked epoxy coating 5 to 6 mils thick.

Corrosion is indexed annually by Engineering Index.

Marine Coatings Tentative Specifications Ready

Numerous Solutions to Splash Zone Problem Weighed by Group

A task group of Unit Committee T-1M on Corrosion of Oil and Gas Well Producing Equipment in Offshore Installations has completed a tentative report on Painting Specifications for Marine Environment. The committee is in general agreement that use of specified detailed specifications for surface preparation and painting and the use of qualified painting inspectors would result in increased quality of coatings systems. Members of T-1M have been invited to contribute additions to the task group's report. The committee has considered the possibility of preparing specifications at a later date covering hot applied coatings and application of Monel sheets at the splash zone.

A member of T-1M has reported the results of an Audigage survey to determine remaining wall thickness of piling in the splash zone of a platform installed seven years ago. The platform is in water 36 feet deep and the deck is 30 feet above the water. The platform members from minus 15 feet to plus 10 feet originally were coated and wrapped in accordance with pipe line specifications. Where the coating was damaged by boats it was repaired with coal tar enamel or coal tar impregnated tape. Results of the survey are shown in Table 1.

It was necessary to file the outer surface smooth to secure reliable Audigage readings. While accuracy of the Audigage is considered to be plus or minus 20 mils, one operator however considered accuracy of plus or minus one mil possible.

The committee feels that offshore structures can be repainted as close to the water as plus four feet but agreed that weather and water conditions would create variations of this in different locations.

Plastic Tape Performs Well

Good performance was reported to committee of a plastic pressure sensitive tape for protection of members in the splash zone. There have been some failures but the best results were secured when the wrapping was started at the bottom. One incident was cited where men standing on a raft wrapped 4-inch tape with a 50 percent overlap from plus two feet to plus five feet. With 50 percent overlap cost of the tape was \$62 per 100 square feet. A polyethylene tape was tried also but lost its adhesion when subjected to drilling mud.

Porcelain enamel was reported to be standing up well on offshore structures in areas not subject to impact. Sheet Neoprene also has given good protection in areas not subject to abrasion. Metalizing failed in one year where pores were not sealed with an inert material.

Impact Damage Is Serious

The problem of protection of structure members and their corrosion resistant coatings from damage by impact or abrasion has been discussed. One company with platforms in 35 feet of water has used protective dolphins separate from the platform structure. In other cases protective piling clusters are

TABLE 1—Corrosion Loss on Platform Piling

Elevation	No. of Readings	Average (MPY*)	Maximum (MPY*)
Plus 2 ft. to plus 4 ft....	27	12	21
Plus 6 ft. to plus 7 ft....	14	12	19
Plus 11 ft. to plus 13 ft....	9	8	11
Outer Legs of Structure			
Plus 2 ft. to plus 4 ft....	12	15	21
Plus 6 ft. to plus 7 ft....	6	11	17
Plus 11 ft. to plus 13 ft....	6	9	11
Inner Legs of Structure			
Plus 2 ft. to plus 4 ft....	15	10	16
Plus 6 ft. to plus 7 ft....	8	13	19
Plus 11 ft. to plus 13 ft....	3	7	8

* Mils per year. (1 mil equal .001 inch)

used. Protective structures strong enough to moor barges and to resist the impact of barges are expensive and the protection of these structures from corrosion is difficult. One solution employed replaceable vertical bumper members fastened to the outside of the outer row of vertical structure members.

Results of a study of the economics of extra-thick structural members in the splash zone versus Monel sheaths has been reported to the committee. It was assumed protection would be required from minus 3 to plus 7 feet. The cost of Monel sheath on 1200 square feet of surface was estimated at \$5500 compared to \$8300 for additional wall thickness of steel in the critical 10-foot zone allowing corrosion of the steel which would not dangerously weaken the structure during its anticipated life. Members of the committee doubted that the corrosion rate of steel at the splash zone could be safely forecast for the anticipated life of the structure. The idea of wrapping a 3/8-inch strip of wrought iron around vertical structure members and welding it in place was discussed. The cost would be about the same as a thin sheet of Monel. Although there are reports of amazing corrosion resistance of lighthouse structures of wrought iron installed a hundred years ago, tests of samples of currently manufactured wrought iron indicate no better corrosion resistance than steel in sea water.

Fastening Sheets Is Problem

The problem of fastening Monel sheets on existing structures at the splash zone has been discussed by the committee. One operator plans to try Monel bands 3 to 4 inches wide to hold the sheets in place. The use of Monel screws to hold the sheets will be tried also.

In a discussion of cathodic protection of offshore structures one operator mentioned using 3000 pounds of magnesium, or .15-pound per square foot to protect an offshore structure. It required from a minimum of 2 to 3 weeks to a maximum of 3 or 4 months to polarize the structure.

Dissatisfaction was expressed by one operator with the results using magnesium anodes attached to the hull of a barge for cathodic protection. He said there was too much local action and the anode life was too short. Another operator reported that of 50 anodes placed on the hull of a vessel, 45 percent were

found faulty because of failure of insulation between the hull and the magnesium or mechanical failure. Another member reported 17-month anode life on a drilling tender and another reported good service of magnesium anodes attached to the hull of a seismograph barge.

One company reported using a rectifier with carbon anodes suspended in the water to protect an LST drilling tender. Pieces of 10-inch pipe split length wise were welded to the side of the vessel at 25-foot intervals to protect anodes and leads from damage. The anodes are suspended about five feet below the bottom of the tender. A recent inspection revealed very little damage to the hull.

Batch Treatment—

(Continued From Page 73)

annulus on a semiyearly basis at a cost of approximately \$25 per well.

Cooperation Gets Results

Cooperative cathodic protection systems among operators in the Western Kansas area indicated reasonably good correlation between down-the-hole potential profile measurements and surface potential measurements. The possibility of interference from nearby cathodically protected structures was pointed out. It has been suggested the area should be watched closely in the future for indications of a more serious problem. A casing leak frequently results in the loss of the well or reduction of the capacity of the well to produce.

One member of T-1H reported his company plans to apply cathodic protection to five leases in the East Texas field containing some 75 wells. He presented photographs showing condition of the recovered casing which indicated the necessity for protection if the present wells are going to produce to normal abandonment without an abnormal number of casing failures. He said the 75 wells had experienced some 10 casing failures to date.

An analysis of corrosion costs to date indicated that for approximately one-fifth of present costs cathodic protection could be applied using 18 and 36 volt, 12 ampere rectifier units with each rectifier handling two wells and withdrawing current in the range of 2 to 3 amperes per well. Problems anticipated included complex interference from a maze of foreign lines throughout the field, but it was believed that careful location of ground beds and resistivity studies will solve these problems.

Another company operating in the East Texas field reported that casing leaks had occurred in approximately 10 percent of its wells. The leak frequency curve indicated an extremely severe problem for the future. A representative reported one test well had been placed under cathodic protection and the casing would be pulled in the very near future for inspection. It was anticipated that some 157 wells located on six leases on six leases on which approximately 70 percent of the casing failures had occurred would be placed under cathodic protection in the near future.

More than 230 authors contributed to the Technical Section in Volume 11, Corrosion.

5000 psi Condensate Well Problems Probed

Some Reports Heard On Earlier Attempts To Reduce Corrosion

Unit Committee T-1B on Condensate Well Corrosion has announced a decision to undertake study of controlling corrosion in wells where the pressures are in excess of 5000 psi. A questionnaire is being prepared for circulation to all companies known to be operating such wells. This decision was made at the committee's meeting in New York during the recent NACE Conference.

Data presented on wells with extremely high pressure included: Nine percent nickel steel tubing is giving good service except for the tendency for a few pits to form near the entrance of safety chokes. Iron content of produced water is at levels similar to that of typical untreated condensate wells. N-80 tubing coated internally with baked phenolic coatings appears to be giving satisfactory service except for severe "erosion-corrosion" at the entrance to safety chokes. Special pack-offs to protect the damaged areas have deferred workover jobs and other special devices are being tried to avoid the erosion. The reported iron content of the produced waters is 10 to 25 ppm or at a level equal to about 10 percent of the level expected in uncoated tubing.

Hardness Variations Cause Cracking

One operator installed about 15 strings of 9 chromium-0.5 molybdenum tubing in one field where pressures were about 8500 psi. The true corrosion behavior of the field has not as yet been determined but two of the strings have failed, presumably due to cracking as the result of unsatisfactory heat treatment. This was indicated by variations in hardness and probably too high a hardness. The operator plans to try using 2½ N-80 tubing with a 1½ or 1¼ macaroni string with inhibitors to control corrosion. It was suggested that 9 chromium-1 molybdenum might be better than 9 chromium-0.5 molybdenum, but there is insufficient data available to permit valid comparison.

Other discussions at the meeting included use of "concentrated" inhibitors with indications they may have merit in certain cases. In one instance where the inhibitor was placed by a wireline dump bailer it was believed the chemical reached the bottom of the well and that two treatments per month gave good results.

Melting Point of Sticks

In a discussion on the use of organic stick inhibitors the fact was mentioned that where the solubility in condensate is good, it is practical for the stick to have a melting point 50 to 100 F higher than the reservoir temperature.

W. H. Edwards, Superior Oil Company, Houston, Texas has been elected chairman of T-1B and D. R. Fincher, Tidelands Associated Oil Company, Weimar, Texas has been elected vice-chairman. Edwards and Fincher took office on the last day of the New York Conference. Next session of the committee will be in San Antonio, Texas during the South Central Region Meeting October 23-26, 1956.

Three Task Groups Formed By Inhibitors Committee

Unit Committee T-3A on Corrosion Inhibitors has announced formation of three task groups. Task Groups and their officers are: T-3A-1, General Theory of the Action of Corrosion Inhibitors, W. W. Sweet, Colgate Palmolive Co., Jersey City, New Jersey, chairman; T-3A-2 on Methods of Testing and Screening Corrosion Inhibitors, chairman to be selected; T-3A-3 on Materials Available for and Application of Corrosion Inhibitors, Lyle Timm, Sharples

Chemicals, Inc., Wyandotte, Mich., chairman.

Task groups will survey published literature and circulate questionnaires to establish information on which nothing has been published.

T-3A will again sponsor a symposium on Corrosion Inhibitors at the 1957 NACE Conference. George E. Best, Mutual Chemical Division, Allied Chemical and Dye Corporation, Baltimore, Md., will be chairman of the symposium.

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19 Committees Schedule San Antonio Meetings

Nineteen committees have asked for meeting space during the 1956 South Central Region Meeting scheduled at the Gunther Hotel, San Antonio, Texas, October 23-26. Because space is limited all committees that want to hold meetings and have not made space reservations are urged to do so as soon as possible. Space may be reserved by writing to T. J. Hull at the NACE Central Office.

Committees scheduled to meet are: T-1, Corrosion in Oil & Gas Well Equipment; T-1B, Condensate Well Corrosion; T-1D, Sour Oil Well Corrosion; T-1F, Metallurgy; T-1G, Sulfide Stress Corrosion Cracking;

T-1H, Oil String Casing Corrosion; T-1J, Oil Field Structural Plastics; T-1K, Inhibitors for Oil and Gas Wells; T-1M, Corrosion of Oil and Gas Well Producing Equipment in Offshore Installations; T-2C, Minimum Current Requirements; T-2D, Standardization of Procedures for Measuring Pipe Coating Leakage Conductance; T-2E, Internal Corrosion of Product Pipe Lines and Tanks; T-3A, Corrosion Inhibitors; T-3G, Cathodic Protection; T-5C-1, Corrosion by Cooling Waters, South Central Region; T-5D, Plastic Materials of Construction; T-6B, Protective Coatings for Resistance to Atmospheric Corrosion; T-6D, Industrial Maintenance Painting; T-6E, Protective Coatings in Petroleum Production.

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Lightning and Fault Current Grounding Will Be Investigated

Unit Committee T-4A on Effects of Electrical Grounding on Corrosion has announced formation of two new task groups. The task groups and their assignments are: T-4A-1, to prepare recommendations for materials to be used for electrical grounding to reduce corrosion; T-4A-2, to draft recommendations for grounding on private premises.



Stilley

T-4A-1 was formed after a discussion of the things that should be considered in electrical grounding with respect to handling of lightning surges, power fault currents and static electricity and how these affect personal safety. It was the opinion of the committee that the public has been put to considerable expense because of the increased corrosion caused by the use of ground materials that increase galvanic action on underground structures. Since grounding on private premises may involve circumstances different from normal power grounding it was decided to form T-4A-2.

T. R. Stilley has been elected to replace R. M. Wainwright as chairman of T-4A. Mr. Wainwright, while retaining his status as an active member of T-4A resigned the chairmanship because of the press of other work. Mr. Stilley is Field Service Manager for the Electrical-Mechanical Division of Good-All Electric Mfg. Co., Ogallala, Nebraska. Previous to January 1, 1956 he was Corrosion and Standards Engineer for the Illinois Power Company, Decatur, Ill. After Naval service from 1943-1945, he attended Marquette University and received the B.E.E. degree in 1947, completing a year of law work one year later while serving as an instructor in electronics at Marquette University.

In 1948 he joined the engineering staff of the Shell Oil Co. at the Wood River Refinery where he did corrosion control work and special electrical designs. In 1950 he joined the engineer staff of the Illinois Power Co. where he did work on electrical design and later assisted in organizing that company's corrosion control department for the gas division. Since 1953 he has also acted as television instructor for adult vocational courses in Decatur. He is a member of the AIEE, AGA and NACE. He is co-author of the Corrosion Manual for the Illinois Power Company.

Atomic Group Is Formed

The Society of Industrial Chemistry, 28 Rue Saint Dominique, Paris VIIe, France has organized an international "Nuclear Energy Group" for the purpose of exchanging information on the progress of the atomic energy sciences.

Plastic Conference Set

Walter J. A. Connor, vice-president and director of American Plastics Corp., has been named chairman of the technical conference on plastics to be held in New York City June 11-15.

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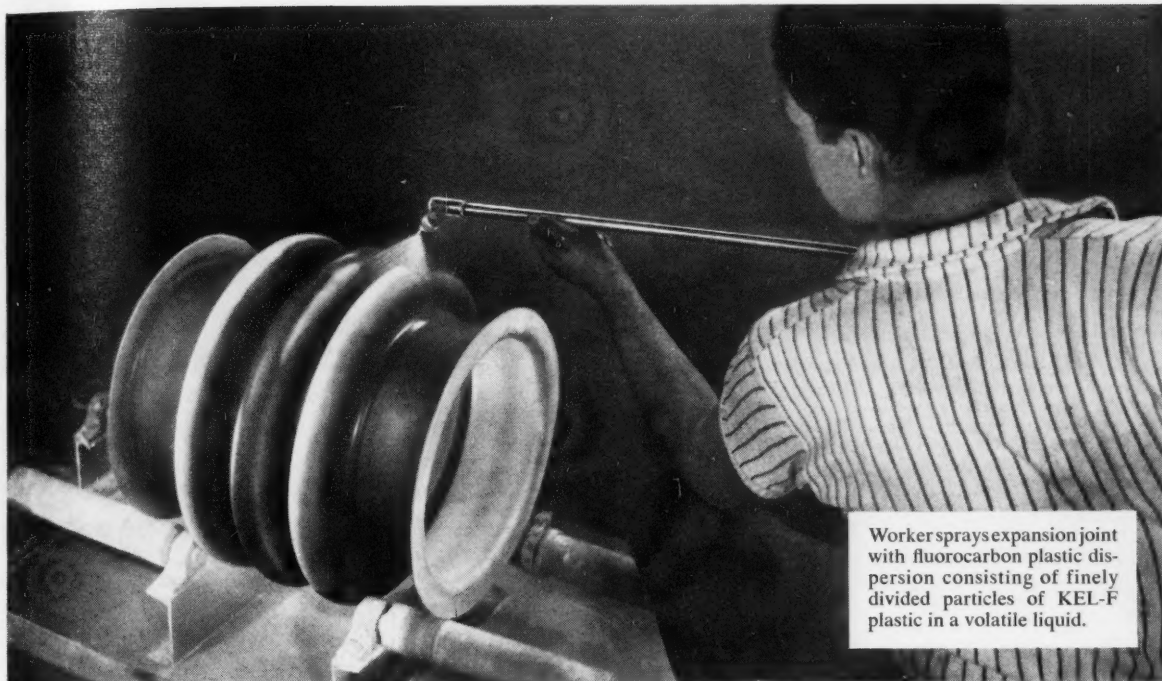
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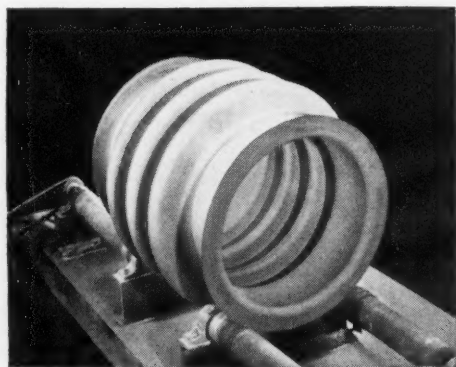
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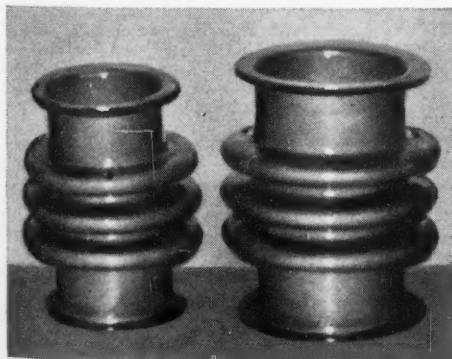


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Epoxy and Semi-Vitreous Coatings Hold Up Well in Wasson Area Oil Tanks

It has been reported to Unit Committee T-1D on Sour Oil Well Corrosion that epoxy and semi-vitreous coatings are holding up well in tanks in the Wasson area. General discussion brought out the consensus that the question of effectiveness of ammonia injection into tanks to reduce vapor phase corrosion has not been resolved. In some cases excellent results have been obtained, but in other cases it appears that corrosion has been accelerated.

In a discussion of internal casing corrosion an instance where cut-back road oil was used to establish a protective film was reported. The oil was pumped into the tubing-casing annulus at a high rate, so as to completely cover the outside of the tubing and inside of

the casing. Tubing was pulled for inspection of the film which appeared to be complete. The film thickness was not determined.

The need for emphasis on the pump corrosion problems was discussed at the T-1D meeting in New York. It was pointed out that the number of parts for pumps is limited and many of the parts from different sources are interchangeable. The committee has appointed a task group whose assignment is to prepare an orderly arrangement of information that will make it easier to select and obtain pump parts.

R. E. Lembcke, Cities Service Research & Development Co., Tulsa, Oklahoma has been elected chairman of T-1D. J. V. Gannon, The Texas Co., Midland, Texas has been elected vice-chairman. Mr. Lembcke and Mr. Gannon took office on the last day of the New York Conference.

Copies of Corrosion's 10-Year Index can be ordered now.

Coatings Committee Elects New Officers



Whiteneck



VanDelinder

L. L. Whiteneck, Long Beach Harbor Department, Long Beach, California has been appointed chairman of NACE Technical Group Committee T-6 on Protective Coatings. Mr. Whiteneck succeeds A. J. Liebman who had been chairman of T-6 for the last two years.

Mr. Whiteneck has been a member of NACE since 1948 and has been very active in NACE affairs. He has served as chairman of the Western Regional Division and as NACE director representing the Western Regional Division. He has been active in several T-6 unit committees and has served as vice-chairman of T-6 for the last two years.

L. S. VanDelinder, Carbide & Carbon Chemicals Co., South Charleston, West Va. has been elected vice-chairman of T-6.

New Unit Will Work on Process Industries' Painting Problems

Formation of a new unit committee on Industrial Maintenance Painting in the Process Industries has been approved. James C. Coffin, The Dow Chemical Company, Midland, Michigan has been appointed temporary chairman of the unit which will be designated Technical Unit Committee T-6D.

L. L. Whiteneck, chairman of Group Committee T-6 under which T-6D will be organized announces approval of the following scope for the new committee: To discuss, study, report and submit for publication information relative to industrial maintenance painting. To advance the cause of corrosion engineering by informing process industry management and supervisory personnel of the advantages to be gained by sound corrosion control and prevention practices. Emphasis will be placed on protective coatings application and painting programs.

It is anticipated the organizational meeting of the new committee will be held in San Antonio, Texas during the 1956 NACE South Central Region Meeting, October 23-26. Other sessions will probably be held at either the 1956 North Central Region Meeting in Detroit or the 1956 Fall Northeast Region Meeting in Philadelphia at about the same time.

NACE members interested in joining T-6D are invited to contact Mr. Coffin.

Five regional NACE meetings will be held during the fall of 1956.

REPRINTS OF ARTICLES PUBLISHED IN CORROSION

Remittances must accompany all orders for literature the aggregate cost of which is less than \$5. Orders of value greater than \$5 will be invoiced if requested. Add 65c per package to the prices given below for Book Post Registry to all addresses outside the United States, Canada and Mexico. Send orders and remittances to NACE, 1061 M&M Bldg., Houston 2, Texas.

Cathodic Protection and Pipe Lines

- Economic Considerations in Pipe Line Corrosion Control by L. G. Sharpe \$0.50
Mitigation of Corrosion on City Gas Distribution Systems by A. D. Simpson, Jr. Final Report—Effect of Exposure to Soils on the properties of Asbestos-Cement Pipe by Melvin Romanoff and Irving A. Denison \$0.50

Economics

- The Cost of Corrosion to the United States by H. H. Uhlig \$0.50
Relation of Corrosion to Business Costs by Aaron Wachter \$0.50

Inhibitors

- Prevention of Corrosion in Cooling Water by R. C. Ulmer and J. W. Wood \$0.50
Dicyclohexylammonium Nitrite, a Volatile Corrosion Inhibitor for Corrosion Preventive Packaging by A. Wachter, T. Skei and N. Stillman \$0.50

Metallurgical Factors

- Resistance of Aluminum Alloys to Weathering by C. J. Walton, D. O. Sprowls and J. A. Nock, Jr., and Resistance of Aluminum Alloys to Contaminated Atmospheres by W. W. Binger, R. H. Wagner and R. H. Brown \$0.50
Laboratory Studies on the Pitting of Aluminum in Aggressive Waters by T. W. Wright and Hugh P. Godard \$0.50
The Corrosion Behavior of Aluminum by Hugh P. Godard \$0.50
Salt Spray Testing Bibliography by Lorraine Voight \$0.50
Air Injection for Prevention of Hydrogen Penetration of Steel by W. A. Bonner and H. D. Burnham \$0.50
Oxide Films on Stainless Steels by Thor N. Rhodin \$0.50
Stress Corrosion Cracking of Hardenable Stainless Steels by F. K. Bloom \$0.50

Miscellaneous

- Causes of Corrosion in Airplanes and Methods of Prevention by N. H. Simpson \$0.50
Corrosion Control by Magic—It's Wonderful by H. H. Uhlig \$0.50
Why Metals Corrode by H. H. Uhlig \$0.50
Methods of Preventing Corrosion in Sewerage Systems by Ervin Spindel \$0.50
Positive Polarity Grounding of Direct Current Supply Requirements in Mining Traction Systems by Sidney A. Gibson \$0.50
Corrosion Studies on a Model Rotary Air Preheater by G. G. Thurlow \$0.50

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Organization and Administration of a Plant Painting Program by W. E. Chandler and C. W. Sisler \$0.50

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Corrosion Control in Gas Lift Wells. II Evaluation of Inhibitors. By D. A. Shock and J. D. Sudbury \$0.50
Internal Corrosion in Domestic Fuel Oil Tanks by R. Wieland and R. S. Treseder \$0.50

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News about COATINGS for METALS

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New plastisol sprays extra-thick coating

New vinyl coating easy to use

Development of Ucilon* 1400 now simplifies the application of a durable vinyl protective coating to walls, ceilings and the exterior of equipment.

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While applying as easily as ordinary oil paint, it gives extraordinary corrosion, protection. Ucilon 1400 resists acids, alkalis, water and numerous other causes of coating failure. Send for data sheet. **Trade Mark*

How engineers put corrosion resistance into steel drums

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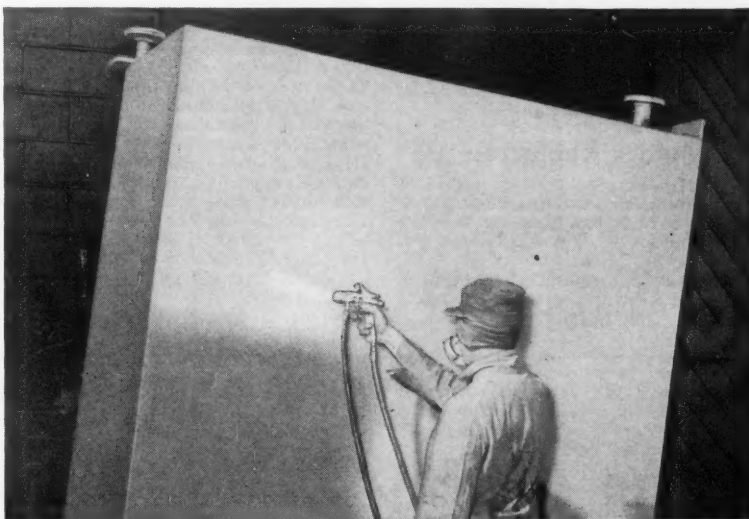
Unichrome drum linings include vinyl, phenolic, epoxy and plastisol formulations. These meet most needs on chemical resistance. Beyond this they satisfy also on the impact resistance, adhesion, film continuity, distensibility and flexibility needed for the service. Engineers need only specify the requirements to have Metal & Thermit recommend the best lining to prevent corrosion and product contamination.



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Unichrome "Super 5300" Coating builds 60 mil film per coat . . . gives heavy duty corrosion-protection



Tank getting a heavy protective coating with Unichrome Plastisol. Large structural parts of products can likewise be durably finished.

A new and unusual plastisol formulation has been developed by Metal & Thermit, a pioneer in this type of coating. Unichrome "Super 5300" Coating delivers the full solids content of vinyl plastisol right through a spray gun. It enables a coat 60 mils or more to be applied successfully in one application.

THICK AND TOUGH

Amounting to a vinyl "sheet" material, single or multiple coats of this new plastisol can be used to good advantage on many of the products where plastic or rubber sheets are generally specified. Super 5300 Coating also provides a durable, protective finish for large uneven surfaces where only a fluid material can be applied. Good performance is assured for two reasons. (1) With spraying, there are no seams or joints where corrosives might penetrate. (2) Vinyl plastisols have a

unique combination of chemical and physical properties.

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Curing quickly at 350° to 365°, Unichrome Plastisols form rugged, resilient coatings with an attractive satin finish. They insulate electrically, absorb impact, don't chip or crack, resist abrasion and erosion, deaden sound.

They give extraordinary protection against a wide range of acids, alkalis, alcohols, salt solutions and moisture. With plastisol protection, ordinary metal parts and products often prove suitable for unusually severe service conditions.

For companies without adequate baking facilities, Metal & Thermit can recommend nearby firms that specialize in applying "Super 5300" Coating. Send for Bulletins that tell more about plastisols.

Stewart Renamed Pipe Line Committee Chairman



Stewart

W. H. Stewart, Sun Pipe Line Company, Beaumont, Texas has been re-appointed Chairman of Technical Group Committee T-2 on Pipe Line Corrosion. Mr. Stewart was reappointed to continue work on the T-2 Minimum Requirements for Protection of Buried Pipe Lines. It is expected the minimum requirements report will be completed this year. L. P. Sudrabin, Electro Rust-Proofing Co., Newark, N. J. continues in the office of vice-chairman of T-2.

F. S. Mulock Reelected

F. S. Mulock was reelected president of the American Zinc Institute. He is president of U. S. Smelting and Refining Co., Boston.

More than 3000 entries are included in the 10-Year Index to Corrosion's Technical Section.



Sudrabin

Utilities Committee Now Headed by Dietze

Irwin C. Dietze, Department of Water & Power, Los Angeles, California has been appointed chairman of Technical Group Committee T-4 on Corrosion in the Utilities Industries.

Mr. Dietze is a native of California. He joined the Los Angeles Department of Water & Power in the underground section of the design and construction division after graduating from the University of California and completes his 31st year with the department this year. During the last 26 years he has been actively engaged in electrolysis and corrosion work.



Dietze

He is a member of the American Institute of Electrical Engineers and of the AIEE Cathodic Protection Subcommittee of the Committees on Chemical, Electromechanical and Electro-thermal applications.

He is chairman of the Electrolysis Committee of Southern California. He has been a member of the National Association of Corrosion Engineers since 1945, in which he has held the following offices: Program chairman of the Western Regional Division in 1947, chairman of the Western Regional Division in 1948, NACE director representing the Western Regional Division for three

years, 1949 through 1951, corrosion correspondent for CORROSION representing the power industry from 1948-1949; chairman of NACE Technical Practices Committee TP-16 in Electrolysis and Corrosion of Cable Sheaths which was organized in 1950. (This committee is now known as Technical Unit Committee T-4B. He has been a member of NACE's Editorial Review Sub-committee since 1953 and served for the last two years as vice-chairman of Technical Group Committee T-4.

Mr. Dietze presented a paper before the NACE Conference in 1947 entitled "Cathodic Protection of 138 KV Lead Sheathed Power Cables in the Los Angeles Department of Water and Power" which was published in CORROSION, September 1947.

A vice-chairman for Group Committee T-4 will be elected by letter ballot soon.

Industrial Packaging Meet

The Society of Industrial Packaging and Materials Handling Engineers will be held at St. Louis Oct. 23-25.

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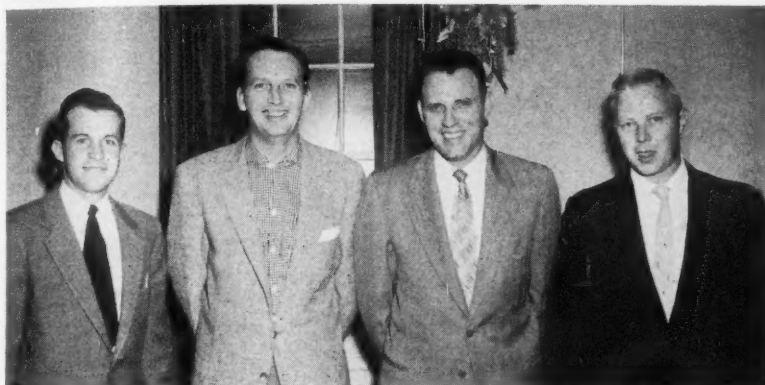
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NACE NEWS



WEST KANSAS SECTION NACE received its charter April 17 from Executive Secretary A. B. Campbell to become the fifty-first NACE section. The meeting, held at Great Bend, Kansas, was attended by 38 members. John W. Nee, Briner Paint Mfg. Co., Corpus Christi, Texas, South Central Region chairman, presented an illustrated talk "Fighting Corrosion Through NACE." The section is the first organized in Kansas. In the photograph the new officers are, left to right, Thomas A. Allan, Cooperative Refinery Association, Great Bend, chairman; J. P. Berry, National Aluminate Corp., Hutchinson, Kansas, secretary-treasurer; W. C. Koger, Cities Service Oil Co., Bartlesville, Okla., trustee and D. L. Peterson, Cities Service Oil Co., Great Bend.



WEST KANSAS SECTION heard Wayne Johnson, Corrosion Rectifying Co., Houston, talk on cathodic protection and its application to pipe lines at its May 3 meeting. The section meets first Thursdays monthly.

Sabine-Neches Section Hears James P. Exum, Jr.

Approximately 25 members and guests attended the April 26 meeting of the Sabine-Neches Section at which James P. Exum, Jr., United Gas Corporation spoke on Corrosion Problems in the Gas Industry. Mr. Exum's talk, which was illustrated with slides, reviewed corrosion problems encountered in the distribution systems of the gas industry and discussed painting of meters and other atmospheric corrosion problems in addition to cathodic protection of underground lines.

Next meeting of the section was scheduled May 24 when new officers of the section were to be elected.

Subscribers to NACE's Abstract Card Service receive cross-indexed abstracts of most of the available literature on corrosion.

Four Symposia Planned for North Central Region's November 15-16 Meeting

Four symposia have been planned for the first meeting of North Central Region to be held at Detroit November 15-16. They are to cover the automotive, electrical power, construction and chemical industries. Several trips to plants also are planned. This information was announced at an April 5 meeting of Detroit Section.

Application of cathodic protection to structures other than pipe lines was discussed by L. P. Sudrabin, Electro Rust-Proofing Corp., Belleville, N. J. His remarks pertained to tanks and relatively large units of other kinds, with emphasis on abnormalities occurring in application of protection. Thirty members and guests were present.

Kenneth Tator of Kenneth Tator Associates, Coraopolis, Pa., was the scheduled speaker for the May 24 meeting on Correlation of Paint Tests Data with Actual Plant Service Life.

Jacksonville Section Elects 1956-57 Officers

Officers elected at an April 13 meeting of Jacksonville Section are as follows: Thomas W. Bostwick, City of Jacksonville, chairman; James W. Dalton, International Minerals and Chemicals Co., vice-chairman and Arthur B. Smith, Amercoat Corp., secretary-treasurer.

On the last Monday monthly luncheons with a different discussion leader for each meeting will be held during the summer. Plans are being made for a 2-day program in the fall.

Northeast Region Sets Oct. 15-17 Corrosion Meet in Philadelphia

New developments in corrosion resistant materials and application of statistical methods to the solution of corrosion problems will highlight the technical program of Northeast Region's October 15-17 Fall Corrosion Conference. The meeting will be held at the Drake Hotel, Philadelphia. Philadelphia and Lehigh Valley Sections are cooperating in arrangements.

Current information on protective coatings, metals and alloys, cermets and plastics and the use of statistical methods in corrosion work will be covered.

Monday, October 15 will be devoted wholly to meetings of NACE technical committees and symposia will be held on the two days following.

Tours of historical spots such as Valley Forge, Independence Hall; a fashion show at Wanamaker's and an opportunity to participate in a live television show will be available to lady visitors.

Data on Instruments Is Atlanta Highlight

Demonstration of the use of instruments in making tests of potentials of buried materials was considered by many to be the highlight of Southeast Region's May 3-4 session at Atlanta, Ga. M. C. Miller, Allendale, N. J., whose presentation was titled "A Short Course in Corrosion Test Instrumentation," set up a galvanic potential series in a soil box and showed differences in potential between metals and the copper-copper sulfate half cell. He had meter cases so designed that potential readings could be projected on a screen. He also showed the effect of reference cell location on the potential reading.

During the tour of the Atlanta water works the group saw corrosion tests which have been in progress for 20 years.

W. M. Stephens, Jr., Georgia Power Co., Atlanta, described cooling water and underground corrosion problems at Georgia Power Company's only salt water plant. Isolation of valves through the use of short sections of plastic pipe and cathodic protection were principal remedies. Some plastic valves are being used.

Items on the technical program were: Corrosion Experience at Plant McManus by W. M. Stephens, Jr., Georgia Power Company, Atlanta.

Corrosion Control in Steam and Condensate Systems by Joseph R. Coursault, W. H. and L. D. Betz Co.

Control of Corrosion in Air Conditioning Equipment by J. S. Livingstone.

Corrosion Control Through NACE, presented by J. W. Nee, Briner Paint Mfg. Co., Inc., Corpus Christi, Texas. A Short Course in Corrosion Test Instrumentation by M. C. Miller, Allendale, N. J.



SPEAKER AND MASTER OF CEREMONIES respectively at the April 17 Chicago Section meeting were, left to right, E. F. Moorman, Engineering and Research Dept., The International Harvester Co. and W. R. Flournoy, Corn Products Refining Co.

Isotope's Use in Corrosion Work Is Topic at Chicago

Techniques of using isotopes in corrosion measurements were described to Chicago Section's April 17 meeting at the Engineers Club. E. F. Moorman, International Harvester Co., Chicago spoke to 65 members and guests on the subject "Use of Radioactive Tracers for Research and Corrosion Work."

Section officers for 1956-57 were nominated and election scheduled for the May meeting. Industrial Coatings Co. was host for the fellowship hour with L. O. Risetter as senior host assisted by L. K. Risetter and Dan Muschott.

After describing the nature of an atom as presently understood, Mr. Moorman enumerated that several ways in which the radiation from isotopes has been used in corrosion investigations. The isotopes usually are employed as tracers, that is they are associated with a component of the environment or material in such a way that the characteristics of the component may be traced through the radiation.

Factors to be considered in designing an experiment using radioactive isotopes are: Statement of problem in detail, why use a tracer?, availability of suitable tracer, preparation of flow sheet, method of detection, detailed plan of manipulation, check on health physics aspects, alternative methods.

Hackerman Discusses Ways to Use Inhibitors

Three commonly accepted means of inhibiting corrosion were discussed at a May 2 meeting of San Francisco Bay Area Section. Norman Hackerman, University of Texas, the technical speaker, also explained practical ways to employ the methods.

A section meeting scheduled June 20 at Alouette Restaurant, San Francisco has a program including a talk on "Statistics of Corrosion Pitting" by G. G. Eldredge of Shell Development Co.

Utilities' Problems Are Covered at New Orleans

The technical portion of the April 17 New Orleans-Baton Rouge Section meeting consisted of a panel discussion of Corrosion Problems in Utilities. The panel was composed of Sydney Trouard, corrosion engineer with New Orleans Public Service Corp.; A. W. Durning, gas superintendent of Louisiana Power & Light Co.; R. J. Dowe, transmission and protection engineer of Southern Bell Telephone Company; M. P. Marsal, field engineer, Western Union Telegraph Co. Moderator was Clifford Barr, Shell Oil Company.

Mr. Trouard discussed the major problems facing the gas, electric and transmission services in New Orleans, while Messrs. Durning, Dowe and Marsal covered corrosion problems connected with gas transmission and underground cables.

Approximately 27 members attended the meeting.

More than 1000 references are indexed in the Alphabetical Subject Index to Volume 11.

Galvanic Corrosion Does Heavy Damage In Georgia Station

Heavy damage to structures in Plant McManus, a 40,000 kw steam generating station located on the Turtle River about 10 miles northeast of Brunswick, Ga. was reported at a meeting of Southeast Region May 3 at Atlanta. W. M. Stephens, Jr. mechanical engineer for Georgia Power Company said he was given control of all corrosion mitigation at his company's steam power plants and that the following events were observed at the McManus plant:

A ¾-inch bronze valve fell off the piping on to the floor, having eaten through Schedule 80 wrought iron pipe in less than four months.

Corrosion due in part to excessive condenser tube vibration caused 300 to be plugged.

Eight months after the plant was put into operation pitting of iron valve seats and discs and corrosion of stems was noted, some of the latter so badly it was impossible to open them.

Piping adjacent to valves was badly corroded.

Seats and discs of valves were replaced with ones as near to the valve body materials as possible in the galvanic series.

Although zinc plugs were provided in water boxes to protect them cathodically, one year after the plant went into operation one of the heater boxes ruptured. Examination showed the cast iron had been graphitized until an almost pure carbon shell remained.

Condensers examined about the same time showed slight pitting on tube sheets and tube ends of condensers indicating the galvanic current had reversed after considerable graphitization of cast iron shells.

Examination of the tubes showed pitting found about two feet from the inlet end of the tube and erosion of the top half of the tube was the result of excessive water velocity and evolution of dissolved air from the water.

Numerous coating systems were tried on surfaces exposed to the atmosphere of which two were found to give good service. One was Neoprene about 10 mils thick and the second an epoxy resin.

After the plant was surveyed by an

(Continued on Page 84)

NOMINATIONS FOR NATIONAL NACE OFFICES

The following have been nominated to the offices indicated in the National Association of Corrosion Engineers by the nominating committee:

W. H. Stewart, President

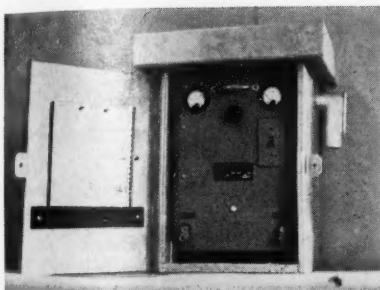
L. L. Whiteneck, Vice-president

A. L. Stegner, Treasurer

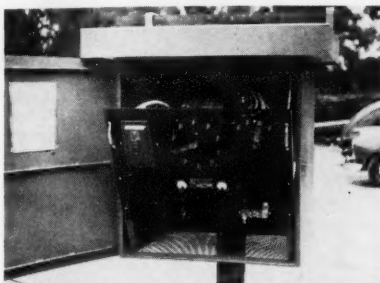
R. E. Kuster and R. S. Treseder, directors representing Corporate members

E. G. Brink, director representing active members

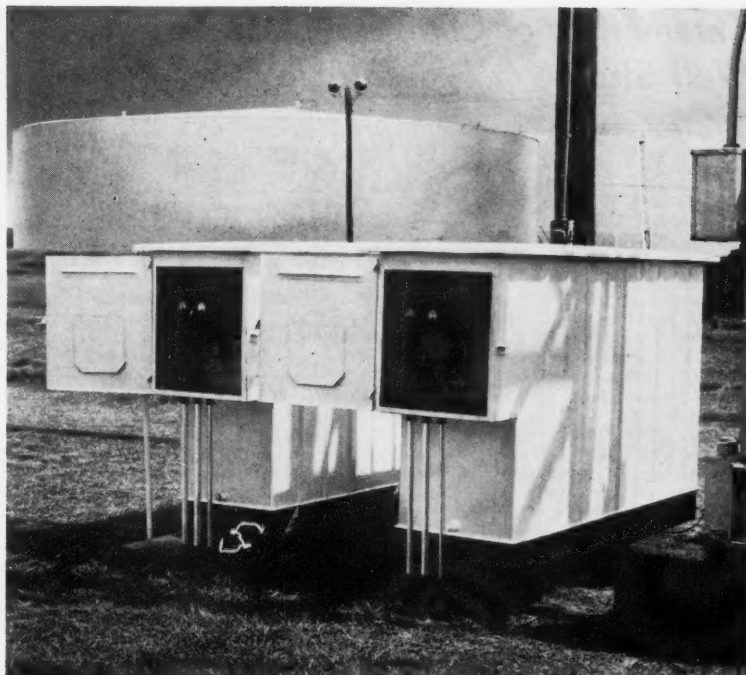
The report of the nominating committee will be mailed to NACE members with a letter from A. B. Campbell, Executive Secretary, dated June 1. Members have until July 6 to prepare and file nominations by petition. Ballots for election of persons to the offices listed will be mailed to members not later than August 27.



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Three-Fifths of Corrosion Damage to Oil Well Structures Preventable, Buchan Says

Three-fifths of the loss suffered from corrosion of oil well structures can be prevented by proper control measures, R. C. Buchan, Humble Oil and Refining Co., Houston believes. Mr. Buchan said in a paper* prepared for presentation at the Third Annual Corrosion Control Short Course, University of Oklahoma on April 4 that expense attributable to corrosion has been estimated at \$500 to \$600 a year per well. This can be reduced to about \$150 to \$200 a year per well by proper measures.

Mr. Buchan described in general terms what the corrosion engineer should be able to do to control damage on oil production equipment. One of his principal difficulties, he pointed out, was separating the extent of damage resulting from corrosion from other factors, such as abrasion, fatigue and obsolescence. While assessing the effect of control measures on surface equipment is not simple, it is far easier than determining what results are being achieved by control efforts expended on buried or submerged equipment, he pointed out.

It is as fallacious to attempt to apply averages to oil wells with respect to corrosion control savings as it is to attempt to apply control measures in-

discriminately among wells without determining the actual need for them. The corrosivity of wells differs substantially not only when one well is compared to another, or one field compared to another, but also from time to time as the character or volume of produced product fluctuates, Mr. Buchan says.

All Should be Corrosion Wise

The problem of corrosion control is not one that ever can be wholly solved, Mr. Buchan believes. Constant checking is required not only to determine whether control measures are being employed as scheduled, but also to determine what effect the controls are having. This means that every person involved in the production of oil should be alert to signs of corrosion damage and see that they are reported to the responsible persons.

Corrosion control of oil well producing equipment should begin even before the well is drilled, Mr. Buchan thinks. Significant savings in equipment sometimes are achieved by controls over the character of the drilling mud, cementing practices, kind of tubing and casing and other items.

Chemicals Produce Savings

Mr. Buchan also reported several instances where research and collaborative investigations have produced data that could be used advantageously in setting up control measures or selecting materials. Strict attention to economics

is necessary in all cases, he pointed out. Inhibitors are believed to have produced savings in condensate wells of as much as \$4000 per year per well. There is some expectation this saving may be increased, he believes.

In spite of all the experimentation that has been done and the numerous kinds of equipment and materials used, the question of lease tank corrosion is far from solved, Mr. Buchan said. Operators seek 20 year service and have tried many ways to achieve it.

Condensate well tubing should last 20 to 40 years, and the cost of annual calipering should be included in any control program.

LaQue Talks on Testing At Baltimore Meeting

F. L. LaQue, The International Nickel Co., Inc. gave the principal address April 10 at a joint meeting in Baltimore of Baltimore-Washington Section of The American Electrochemists Society, The Electrochemical Society and the Baltimore Section, National Association of Corrosion Engineers. More than 125 were present.

Corrosion activities of the sponsoring societies were reported by William Blum, president of the Baltimore-Washington AES Section, M. C. Bloom for the Corrosion Division of the ECS and George E. Best, Northeast Region NACE director for the NACE. Mr. Best reviewed activities of NACE technical committees and underlined the value of abstracts published in the NACE periodical CORROSION.

Mr. LaQue presented an illustrated lecture on Planning and Interpretation of Corrosion Tests. It concerned accelerated and long time tests designed to help in the selection of material suitable for use in corrosive environments. He gave special attention to details that must be considered in planning and interpreting the results of corrosion tests.

Philadelphia Section Plans Three More Programs

Three meetings have been scheduled during the remainder of the 1956-57 season for Philadelphia Section. R. D. Thomas, Jr. is scheduled to speak at a September 18 meeting on Corrosion Resistant Welded Joints in Piping Systems. F. L. LaQue will speak on Design and Interpretation of Corrosion Tests at a December 13 meeting.

Final meeting of the year will be February 5, 1957.

Galvanic Corrosion—

(Continued From Page 82)

engineering firm and cathodic protection applied and after valves were isolated or replaced with plastic valves much of the trouble with corrosion was remedied. Chlorination eliminated troubles with marine organisms. Pitting and erosion of condenser tubes is still being studied. Use of 70-30 cupronickel tubes is being considered because of their good performance in competition with 90-10 cupronickel and aluminum brass.

These facts are extracted from Mr. Stephens' paper "Salt Water Corrosion at Plant McManus."

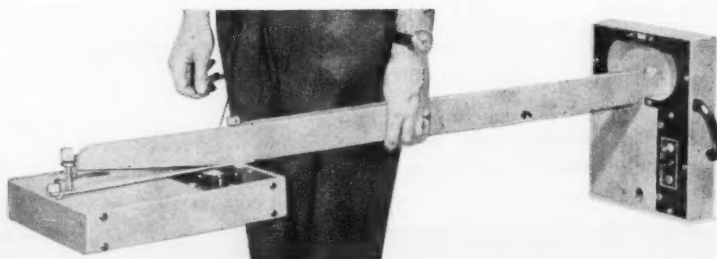
NACE's Abstract Card service has issued more than 10,000 cards.

* Economic Aspects of Corrosion Control in Oil and Gas Production by R. C. Buchan, Humble Oil & Ref. Co., Houston. A paper presented at the Third Annual Corrosion Control Short Course, University of Oklahoma, Norman, April 5, 1956.

The WILKINSON LINE LOCATOR

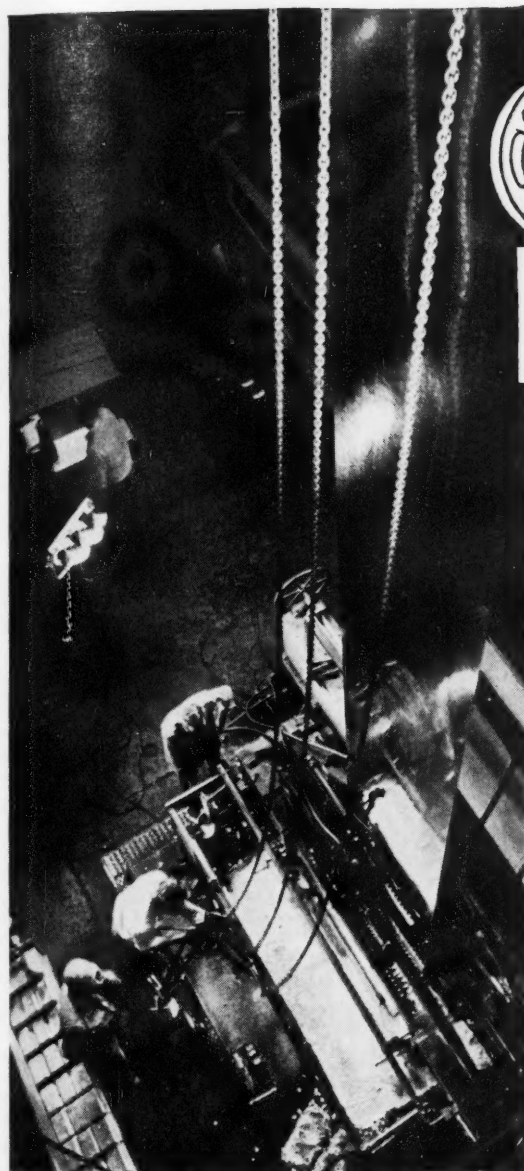
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above: Exit section of continuous galvanizing line. The sheet steel emerges from zinc melting pot.

right: This scene from the film shows the galvanizing of hot water tanks in a bath of molten zinc.



SEE! HEAR! how "Zinc Controls Corrosion"

Corrosion turns many thousands of tons of useful steel to scrap every single year. How this destructive action of the elements on steel can be delayed, minimized and controlled — thus avoiding mounting replacement and maintenance costs — is the subject of a new 16 mm. color and sound movie just released by the *American Zinc Institute*. In its 35 minutes of running time, "Zinc Controls Corrosion" presents a colorful demonstration of the general mechanism of corrosion as well as how zinc controls it.

The film uses the techniques of animation to show that, fundamentally, corrosion is the result of electrochemical action between dissimilar metals or different areas of the same metal. It explains how a galvanic cell is set up between dissimilar areas, or metals, causing the destruction of one of them and the protection of the other. While zinc has a high degree of corrosion resistance, and forms an effective and durable barrier between the steel and the elements, the film graphically illustrates that it is the sacrificial property of zinc in the presence of iron which is the key to the excellent protection which it affords vulnerable iron and steel products. Since the type of structure or product into which the steel is to go, and the kind of corrosive environment encountered, dictates the method of using zinc as a protective metal, the film also shows how steel is coated with zinc by means of galvanizing, electrogalvanizing, spraying, painting, metallizing, sherardizing, and how it is protected cathodically by zinc anodes.

Last, but not least, "Zinc Controls Corrosion" provides a fascinating insight relative to the many reasons why (a) nearly one-half of all the zinc consumed annually in the U.S. is used for the protection of iron and steel products and (b) that no program aimed at corrosion control can be fully effective without considering zinc — the protective metal.

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How to book "ZINC CONTROLS CORROSION"

The film is available for showing — at no charge — before agricultural, industrial, technical and educational groups. Prints can be borrowed from the *American Zinc Institute, Inc.*, 60 East 42nd St., New York 17, N. Y. Booking forms can be had on request.

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Program for LaJolla Marine Course Given

The Conference on Marine Corrosion and Fouling Problems held at Scripps Institution of Oceanography, University of California, LaJolla April 18-21 inclusive listed the following in its technical program:

An Introduction to the Study of Marine Corrosion, Israel Cornet, University of California.

Role of the Corrosion Engineer in Industry and Practice, Paul Beerman, director, Water Department, City of San Diego.

The Physical Chemistry of Corrosion Reactions, Norman Hackerman, University of Texas, Austin.

Fouling Organisms and Their Control in Sea Water Conduits, Denis L. Fox, Scripps Institution.

Marine Corrosion and Fouling, motion picture, James M. Snodgrass, Scripps Institution.

Theoretical Studies and Laboratory Techniques in Corrosion Testing Evaluation, F. L. LaQue, The International Nickel Co., Inc., New York.

Prevention of Corrosion in Naval Aircraft by Stanley L. Chisholm, and Norman A. Rudd, U. S. Naval Air Station, North Island, San Diego.

Pitting Corrosion in Reserve Fleet Ships by Eugene F. Corcoran, and James S. Kittredge, Scripps Institution.

Preparation of Surfaces, F. O. Waters, City of San Diego.

Solving Marine Coating Problems, Lester Morris, Amercoat Corp., South Gate.

Coal Tar Coatings for Marine Use, N. T. Shideler, Pittsburgh Coke & Chemical Co., Pittsburgh.

A Method for the Evaluation of Protective Coatings in Marine Environments, L. L. Whiteneck, Long Beach Harbor Dept.

Principles and Practice of Cathodic Protection by R. E. Hall, Union Oil Co., Brea.

Resistance of Aluminum to Pitting Corrosion in Sea Water by T. J. Summer-son and M. J. Pryor, Kaiser Aluminum & Chemical Corp., Spokane.

Plastic Substitutes for Metals in Marine Environments by John Delmonte, Furane Plastics, Inc., Los Angeles.

Metallurgical and Mechanical Factors in Corrosion by Julius J. Harwood, Office of Naval Research, Washington.

Cathodic protection of external hulls on the reserve fleet was inspected Saturday morning, April 21.

Three Technical Papers Given at Southwestern Ohio Section Meeting

The last Southwestern Ohio Section meeting of the 1955-56 season was highlighted by presentation of three technical papers: David Radcliffe, Barrows Porcelain Enamel Company, "Ceramic Coating"; George Pemberton, Cincinnati Gas & Electric Company, "Underground Coatings" and Cliff Weymiller, Procter & Gamble Company, "Atmospheric Protective Coatings."

Thirty-four members and guests attended the April 24 meeting.

Section officers were installed as follows: Cliff Jones, chairman; Sol Glesser, vice-chairman; William Hare, secretary and R. Leonard Wood, treasurer.

Beiswanger to Head Lehigh Valley Section

John P. G. Beiswanger, General Analine & Film Corp., Easton, Pa., is the new chairman of Lehigh Valley Section for 1956-57. Also elected were Edmund A. Anderson, New Jersey Zinc Co., Palmerton, Pa., vice-chairman and J. Carl Bovan, Atlas Mineral Products Co., Mertztown, Pa., secretary-treasurer.

Names of new officers were revealed at the section's March 26 meeting at which a motion picture was shown depicting the development of the oil fields in Pennsylvania.

The May 26 meeting is scheduled to include a visit to the plant of the Riegel Paper Co., Milford, N. J.

Loeffler to Head Regional Educational Committee

John E. Loeffler, Thornhill-Craver Co., Houston has accepted chairmanship of South Central Region's Educational Committee. He succeeds H. E. Waldrip, Gulf Oil Corp., Houston who resigned because of press of other activities. Mr. Waldrip will continue to assist in the committee's work.



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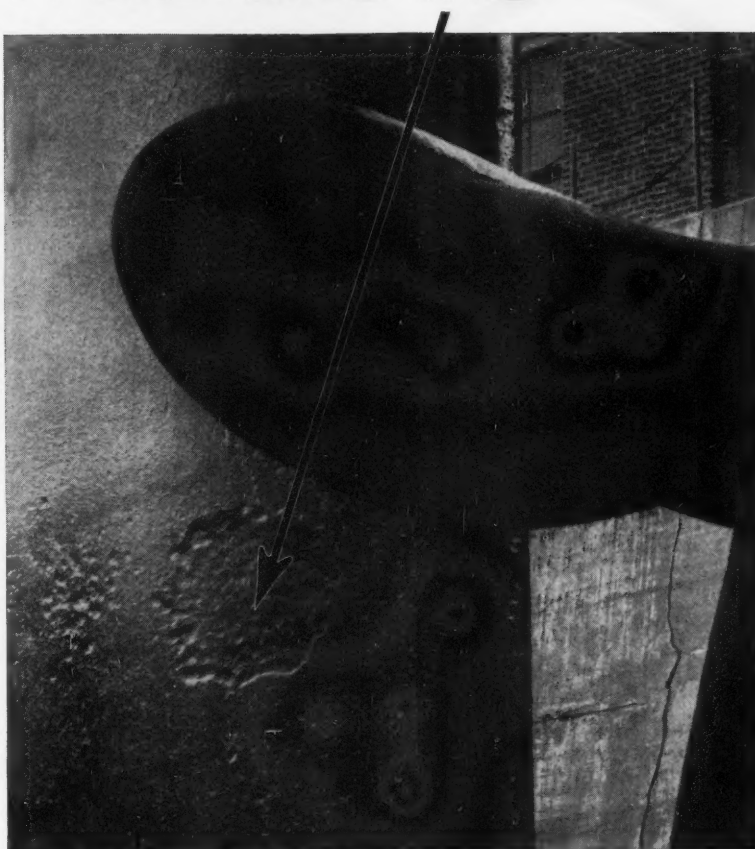
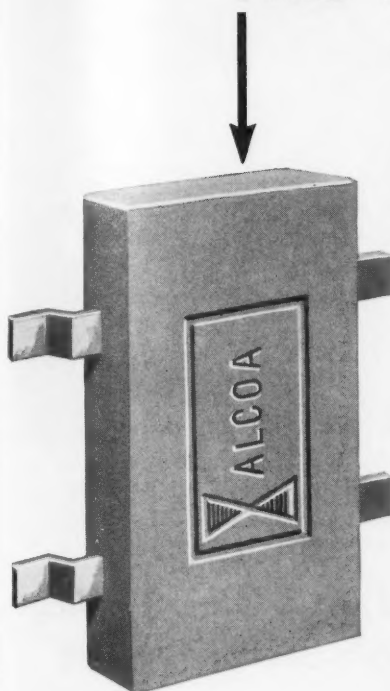
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FUTURE ENGINEER Charles Penn, left, chats with Ed Muehlhouse, center, NACE North Texas Section chairman and Carl Reistle, national president of the American Institute of Mining and Metallurgical Engineers. The photograph was taken at the April 26 banquet for future engineers held at the Dallas Engineers' Club where engineering organizations sponsored some 200 high school seniors. Each boy sat with an engineer from his future field.

Useful Information on Epoxy, Other Coatings Given at Rocky Mountain Section Meeting

Useful information on the nature and use of different types of epoxy and other coatings was given to the NACE Rocky Mountain Section at its February 17 meeting. A. G. Sternberg, Technical director of Steelcoat Manufacturing Co., St. Louis, was the principal technical speaker at the meeting. Some of Mr. Sternberg's comments were:

Current interest is in epoxy finishes. Epoxy resins have been known since before the turn of the century, but it was not until the 1940's that commercial availability of the raw materials (epichlorohydrin and bis-phenyl-A) made commercial production feasible. Development of these resins in commercial operation was the result of independent research by the Shell Chemical Company in conjunction with Devco-Raynolds in this country and the Ciba Company in Switzerland.

Epoxy finishes recently have become prominent due to their great versatility. They have good chemical resistance, adhesion, flexibility and combine in one coating the outstanding characteristics of many other types. Basic raw materials for epoxy resins can be derived from petroleum.

Ether Type Linkages

The chemistry of epoxies is very involved but in short the internal structure contains "ether" type linkages instead of the "ester" type usually found in protective coatings and the "ether" type is the most stable known to organic chemists. This explains the high resistance to attack by water, alkali, aromatic and aliphatic hydrocarbons, alcohols, esters and ketones as well as a wide variety of other chemicals.

Chemical and water resistant properties of epoxies are in many respects very similar to those of vinyl. They have excellent cohesion and yet tremendous adhesion. They are not as "fussy" as the vinyls for perfect surface preparation. Their adhesion, however, ex-

ceeds their cohesion and even when peeling is manually started they cannot, normally, be stripped from a panel. They are fairly light colored and may, therefore, be colored with almost any chosen pigment except, of course, where the inherent limitations of the pigment causes a reduction in the chemical resistance of the film.

The film is exceedingly resistant to ultra violet light. Unlike other clear finishes the accelerated test results indicate that the Epoxy Clear is almost as resistant to degradation as the pigmented films. Steelcote had panels in under accelerated test for over 3000 hours after which they were restored almost completely by the application of automobile polish.

The five basic paint formulations in the epoxy group designed to do specific jobs are esters, amines, polyamides, ureas and phenolics.

Similar to Phenolic Varnishes

Epoxy esters are the most common one-package system. They are very similar to phenolic varnishes except that they retain color better. Epoxy esters dry well and speedily according to the amount of epoxy resin present. This factor also controls their chemical resistance. Well formulated esters have excellent resistance to detergents, mild acids and alkali, aromatic and aliphatic solvents and furnish a hard, yet flexible surface which has excellent adhesion. Epoxy esters are the reaction products of epoxy resins and drying type fatty acids, usually tall oil, but frequently soya, linseed, or castor fatty acids. Modifications may be made as low as 5 to 10 percent and as high as 40 to 60 percent. Naturally as with any modifying resin, film properties primarily are those of the major constituents.

Epoxy amines probably are the most widely produced of the two package types. One of the two packages con-

(Continued on Page 90)

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Useful Information—

(Continued From Page 88)

tains the amine curing agent which can be toxic to some people while the other contains the epoxy resin. It is easy to identify the amine-cured from the amide since the curing agent of the former is comparatively light colored and there is less of it. The film is glossy, durable and has excellent adhesion. They air dry to handle in from 2 to 6 hours at normal room temperatures but do not develop chemical resistance for about a week. Of course, the speed of the cure is greatly accelerated by even slight increases in temperature. This works the other way also, in that slight decreases greatly retard the cure. They may be formulated specially to cure as low as 40 F, but normally the cure below 50 is exceedingly slow.

On the other hand the complete cure may be accelerated to as fast as a few minutes by raising the temperature into the force drying range of 140 to 200 F. Epoxy amines are known best for their resistance to all solvents except the chlorinated types and they have good resistance to other chemicals as well. They are somewhat more brittle than either the epoxy esters or polyamides, but they will withstand high impact and more than normal abuse on structural steel.

Polyamides Are Versatile

Epoxy polyamides are noted for their hard, durable and flexible films and are the most versatile of all the epoxy groups. They are the outstanding air dry finish for resistance to acids, alkali and other chemicals, to abrasion and solvents. This product has withstood with-

out crazing the equivalent of almost a decade the action of rain, and sun. The polyamide curing agent in its concentrated form is far less toxic than is the amine. In addition, the polyamide itself is a resin of relatively low viscosity therefore it adds considerably to the solids and the thickness of each coat. The epoxy-polyamide is a 2-package system and like the epoxy-amine, the cure is very sensitive to temperature change. Steelcote's experience is that the drying time below 50 F is far too slow to be practical.

This particular chemical combination has a very peculiar effect on water wet surfaces either by condensation, or where washed and not allowed to dry. Concrete surfaces such as basement floors may be painted easily by thoroughly washing the concrete with detergent and water, flushing down and not allowing to dry.

Cures Under Water

An example of the epoxy-polyamide applicability may be seen in the case of a large Southern power company who painted its penstocks with this material. These were pipes five feet in diameter and some 640 feet long. The air temperature was in the upper 90's, but the pipe temperature was only 50 degrees. This caused continuous and heavy sweating and made it impossible to dry the pipes long enough to apply the paint. In spite of this, the coating went down to the surface, displaced the water to the top and proceeded to cure under the water. It became hard enough for a second coat within two hours even though it actually did not truly cure for weeks.

A fourth commonly used variety of epoxy is the urea cured. In this case the

urea also acts with the Epon but not at room temperature, therefore, it may be furnished in one package. The reaction takes place only at temperatures above 275 degrees. It gives a flexible, chemical, mar and abrasion resistant film, with fine adhesion and the excellent color retention of the ureas. This type, or a combination of epoxy-esters and ureas, is the material that normally is used for original product finishes such as the primer on the inside of washing machines or on laboratory furniture. Experience has indicated that a washing machine interior primed with this material may be coated as thinly as one third the mil thickness ordinarily used and still give an improvement in alkali, soap, water and detergent resistance at a considerable saving in the material used, even though the cost per gallon is somewhat higher.

Phenolics Have Good Qualities

The epoxy-phenolics combine the alkali resistance, flexibility and adhesion of the Epons with the acid resistance and hardness of the phenolics. Unfortunately, the poor color of the phenolic is also transmitted. This type is generally one of the most chemically resistant of all organic coatings available today and is used in lining tank cars. This material must be cured at a relatively high temperature. In fact, complete cure does not take place until the temperature nears 400 degrees.

Descriptions of the epoxy paints by no means ends the discussion of epoxy coatings. Other uses have been found for epoxy resins. At 100 percent solids they are being used for potting, molding and filling and are even strong enough to make dies suitable for stamping steel. With this 100 percent solids resin it is possible to add steel, aluminum, or any metallic powder or colored pigment and achieve a "putty" that has no shrinkage, oil loss, or slump. It becomes so hard that it may be filed, stamped, drilled and tapped. Imagine the possibilities of this as an economical way to round off the inside of square tanks so that unused matter will not gather in the corners making cleaning difficult. The adhesion of this material to metal, wood, concrete, plaster, etc., is so great that it must be chisled off in order to remove it.

Epoxy resins or any other coating material are not the whole solution to the corrosion problem of metal surfaces. All coatings are permeable to water to a greater or lesser degree, more permeable to ions in the water and especially to the ions of acid, alkali or salt. These ions are trying to get to the surface of the metal and will pass thru pores too small to be called pinholes or openings, but through pores of the coating itself.

Moisture Will Get Through

Probably the least transparent of all are the epoxy-phenolic based combinations. However, even these combinations can be demonstrated to pass a certain amount of water ions and over long periods when submerged eventually will permit moisture to get under the film. All air-dry coatings, however, admit moisture faster. When these coatings are used on structural work the amount of moisture passed out is probably approximately equal to or the amount passed in and therefore is normally ignored. However, when used as a tank lining, no moisture can be passed out

(Continued on Page 91)

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Useful Information—

(Continued From Page 90)

and the only exit is toward the metal. Therefore, something must be put next to the metal which will absorb or make ineffective this moisture.

Pigments Aid Protection

The solution here seems to be one of pigmentation. Pigments are chosen normally for appearance primarily, but in the case of corrosion resistance the choice becomes much more important.

Many methods are used for this. One is a layer of zinc chromate on the metal as is done with a vinyl wash primer. Unfortunately, however, zinc chromate itself, is too reactive and will not absorb sufficient moisture in most tank lining applications and therefore, it is not advisable except in the peculiar case of vinyls.

Zinc chromate probably actually reacts chemically with the phosphoric acid and the particular vinyl used to form a complex compound of different properties than any of the ingredients. When zinc chromate is used in a material with which it does not react in the same way, such as Parlon, phenolics, chlorinated rubber or Epon, it disappears too fast and forms compounds with the water, which actually interferes with rather than helps adhesion of the system.

Zinc Dust Is Useful

Zinc metal, as is well known, forms an excellent protective coating on metal. Of course zinc is well known in industry for protection in the form of galvanizing. However, galvanizing is not always possible to attain, especially on a structure that is already in place. In addition, galvanizing has the bad fault of not holding very well to protective coats which are placed over it. Excellent and similar results have been obtained by using exceedingly large amounts of zinc dust (actually in excess of 90 percent of the finished dry film) with the balance, the adhesive portion, an epoxy combination (preferably the epoxy-polyamide). The high dielectric strength of the epoxy probably slows down the rate of reaction of the zinc somewhat but it doesn't slow it to the point beyond which it does not protect the metal. It simply slows it to the point where it will last longer.

In addition, it gives a finish which, while it might be described as somewhat rough, at least has enough organic matter in it to permit excellent adhesion of succeeding coats. Steelcote has obtained best results for anti-corrosion, therefore, by using a coating of zinc dust pigmented epoxy finish against the metal to take care of what moisture does get in and then putting as good a coating over this as possible to permit as little moisture as possible to enter, thereby improving the overall life.

Zinc has such a powerful sacrificial anti-corrosive effect that even though the film is scratched through to the metal, it will blanket the scratch and prevent corrosion until it is used up, usually giving ample time for repair.

Some other pigments, namely red lead, basic lead chromate and potassium-barium chromate also will prevent or reduce corrosion at the scratch but most of these are either more soluble in water (they blister) or more toxic than zinc metal. Zinc, however, is only

(Continued on Page 92)

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Useful Information—

(Continued From Page 91)

effective below 140 F continuous exposure. Above this point its electromotive potential reverses and it will cause corrosion. It is also not effective for long periods under either highly acid or highly alkaline conditions. It works best from pH 4 to pH 11.0. In the case of the high bake Epon phenolic, this material seems to be resistant enough to water ions, making the concern over penetration unnecessary so long as the coating is thick enough. In a case like this, multiple coats are used, frequently as high as 10 or 12.

The theory of the zinc dust coating is to absorb moisture and on this theory its life, of course, will be greater the less moisture that is allowed to reach it.

The second coat should, therefore, be chosen with the idea of admitting minimum moisture or ionic transmission.

Iron Oxide a Desirable Coat

For this second or intermediate coating, pigments must be chosen which both have minimum swelling in water and minimum moisture transmission. Epoxy polyamide clear is excellent here but a few pigments actually improve these characteristics. Red and white lead are among the best, both from the standpoint of swelling and moisture transmission but are expensive, toxic and frequently reactive. Aluminum pigment is excellent in retarding moisture passage but swells and has poor alkali resistance. Titanium dioxide passes moisture badly and swells somewhat. Iron oxide is low cost, almost as good as the leads in

resisting swelling and moisture transmission. In addition, iron oxide makes a desirable, light-fast finish coat, if desired.

The top or finish coat is chosen primarily to give the color a decorative effect if desired, or some other characteristic such as reflectivity. The only limitation here is choosing pigments of suitable durability for the conditions. Most color schemes today tend to be light and so the base pigment should be titanium dioxide together with color pigments desired.

No Finish Is "Cure All"

As has frequently been said, no one finish is a "cure all" but as may be seen above, epoxies come as close as any known today and have advantages over a wider variety of end uses than have most finishes. They have excellent general chemical resistance, both to acids and alkalis; they cure to a hard, durable finish; they are relatively easy to apply; and they may be modified to have specific resistance to still wider ranges of chemicals.

For maximum corrosion resistance to water, salt, acid or alkali and on a surface which may be allowed to dry, as structural steel, and the exteriors of tanks, the finish should consist of: first (after cleaning) a rust inhibitive coat, second a moisture barrier coat and third a decorative coat. In the interest of economy, if any of the coats are eliminated, it should be the last. Also, provided only that the finishing coats are themselves resistant to the atmosphere encountered, they may be any of a number of materials, but the most durable first coat on the steel is the zinc dust epoxy coating. The best procedure available today for air dry immersion is similar to the above except that all coats should be doubled and a minimum of five used.

Kel-F Is Topic at May Meeting in Pittsburgh

F. J. Honn, M. W. Kellogg Co. spoke on "Kel-F for Corrosion Control" at the May 3 Pittsburgh Section meeting, last of the 1955-56 season. Officers were elected also as follows: L. G. Royston, Royston Laboratories, Inc., chairman; A. B. McKee, Aluminum Research Laboratory, vice-chairman; Sumner H. Kalin, U. S. Steel Corp., secretary and R. W. Maier, Gulf Oil Corp., treasurer.

"Dutch treat" informal dinners held prior to meetings by the section provide an opportunity for association among members and permit them to get acquainted with speakers.

Kansas City Has Panel on Interference Problems

"Interference Problems with Rectifiers in Urban Areas," was the topic of a panel discussion at the April 30 meeting of Kansas City Section. About 37 members and guests heard the panel, moderated by John Barringer of Panhandle Eastern Pipeline Co., and consisting of Robert R. Hancox, Great Lakes Pipeline Co.; Fred Few, Southwestern Bell Telephone Co. and Harry A. Norton, Western Union Telegraph Co.

At a showing March 19 of the Inco motion picture "Corrosion in Action" about 15 members and guests were present.



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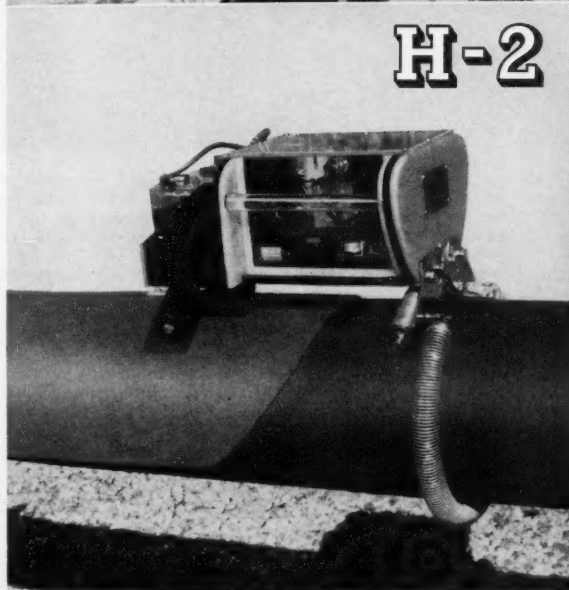
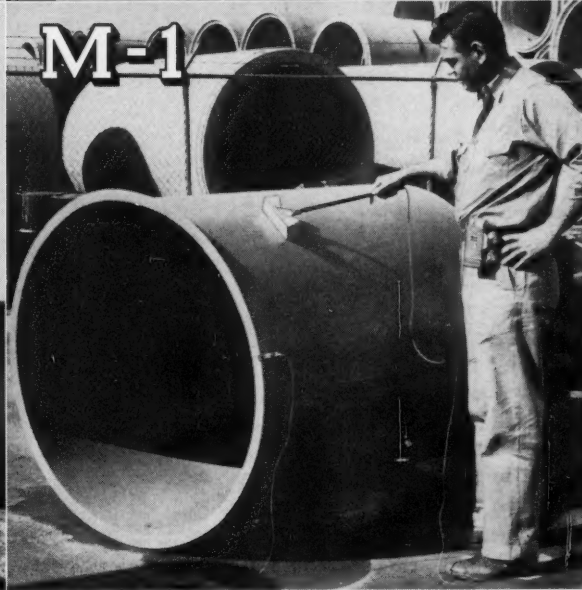
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Bennett Is Correspondent

H. Howard Bennett, Socony Mobil Oil Co., Paulsboro, N. J., is now correspondent for CORROSION in the petroleum refining field replacing C. F. Pogacar, Atlantic Refining Co., Philadelphia.

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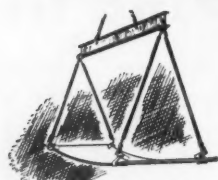
NIAGARA FRONTIER SECTION'S Spring Symposium May 9-10, which had a registration of 168 included a technical program that brought many favorable comments. Shown in the top photograph are members of the panel organized for a discussion session. Members are, left to right, H. O. Teeple, The International Nickel Co., Inc.; E. D. Weisert, Haynes-Stellite Co.; W. O. Binder, Electro Metallurgical Co.; Milton Stern, Electro Metallurgical Co.; S. H. Kalin, U. S. Steel Corp., and C. P. Dillon, Carbide and Carbon Chemicals Co. The lower photograph shows some of the persons who attended luncheon at the University of Buffalo.

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SILVER PRIMOCON

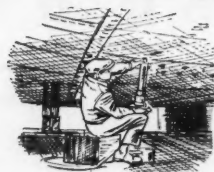
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NATIONAL, REGIONAL MEETINGS and SHORT COURSES

1956

Oct. 15-17—Northeast Regional Meeting, Philadelphia.

Oct. 23-26—South Central Region, Gunter Hotel, San Antonio, Texas.

Nov. 15-16—North Central Region Meeting, Detroit, Mich.

1957

Mar. 11-15—NACE Annual Conference, Kiel Auditorium, St. Louis, Missouri.

1958

Mar. 17-21—NACE Annual Conference, Civic Auditorium, San Francisco, California.

1959

NACE Annual Conference, Sherman Hotel, Chicago, Illinois.

Nobler Metals Used More Often to Limit Corrosion

Nobler metals are being used more often than formerly in corrosive environments, Frederick W. Fink, assistant chief of the Corrosion Technology Division of Battelle Memorial Institute told 25 members and guests present for the March 27 meeting of Southwestern Ohio Section. Mr. Fink showed numerous graphs indicating rates of corrosion of various metals.

Alfred D. Jess, Ampco Metal, Inc., section chairman, reported on activities at the NACE Twelfth Annual Conference.

The scheduled April 24 section meeting is the last planned for the 1955-56 year.

Swearingen Will Address San Antonio Meeting

Judson S. Swearingen, director of the petroleum division, Southwest Research Institute, San Antonio, will discuss "Science City" a description of the work of the institute with which he is connected during the South Central Region meeting in San Antonio. His talk is scheduled for the annual regional business luncheon October 26.

30 Bay Area Section Members Attend Meeting

Approximately 30 NACE members and 200 American Society of Metals members attended a joint meeting of San Francisco Bay Area Section NACE and ASM April 4. A discussion by J. B. Rutherford on The Application and Limitations of Metals in the Petroleum and Chemical Industry was presented.

Carolinas Section to Meet June 8 at Wrightsville

A meeting will be held June 8 by Carolinas Section at Wrightsville Beach during the 1956 Marine Borer Conference sponsored by the Sea Horse Institute. A business meeting and dinner will be held by the section.

Members of Southeast Region NACE also have been invited to attend the conference and the section meeting.

Houston Outing Is Held

Members of Houston Section, their families and friends were guests at the annual section outing May 7 at Tennessee, recreation center of Tennessee Gas Transmission Corp. Barbecue dinner and dancing were featured. A golf tournament was held during the afternoon.

Topical Indices to the material published in the Technical Section of Corrosion are published annually in the December issue.

Alphabetical author indices in the December issue of Corrosion include titles of papers written by or discussed by persons listed.

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IF IT'S
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PROTECTING
IT'S WORTH
PROTECTING
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For positive protection of pipelines and other underground metal structures, use Federated Magnesium Anodes. Note these exclusive features:

- Patented electro-galvanized, spiral wound strip core is completely bonded to the magnesium alloy for perfect electrical contact.
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- Silver soldered, connecting wire joints provide dependable, high-strength low-resistance joints.

Federated makes the widest selection of magnesium anodes in the field. All regular sizes and specifications are available, and special requirements can be met.

A complete line of zinc anodes is also available made from Special High Grade low iron anode zinc.

Corrosion Advisory Service is at your disposal through Federated's 13 plants and 23 sales offices.

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DIE CASTING METALS, LEAD AND LEAD PRODUCTS, SOLDERS, TYPE METALS



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GENERAL NEWS

Method Developed to Keep Continuous Record of Water Vapor in Gas

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The method was developed by the research and engineering departments of Mine Safety Appliances Co., Pittsburgh and Esso Research and Engineering Co. Charles W. Skarstrom was in charge of development for Esso. Applications include measurement of water in natural gas in long pipe lines, in maintaining efficiency of drying towers and to prevent moisture damage in process industries by monitoring feed streams.

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Widespread Interest in Air Pollution Is Growing

Continuing and widespread interest in problems associated with air pollution is evidenced by several recent events among which are the following:

At an April 25 meeting in Washington coordination of air pollution research activities of the Department of Health, Education and Welfare with those of other federal agencies was discussed. The meeting of the interdepartmental committee on Community Air Pollution included representation from the Departments of Agriculture, Commerce, Defense and Interior, Atomic Energy Commission and National Science Foundation. Public Health Service Deputy Surgeon General W. Palmer Dearing presided.

At a May 19 meeting in Austin, Texas the Third Industrial Hygiene Conference on "Air Pollution" was held. Six formal technical papers on various aspects of pollution and two panel sessions were held.

American Society for Testing Materials announced publication of test methods of interest to industry and local air pollution control authorities:

Method of Determining Concentration of Odorous Vapors. (Tentative) D 1354—55t.

Methods of Continuous Analysis and Automatic Recording of the Sulfur Dioxide Content of the Atmosphere. (Tentative) D 1355—55t.

Definitions of Terms Relating to Atmospheric Sampling and Analysis. (Tentative) D 1356—55t.

Recommended Practice for Planning and Sampling of the Atmosphere for Analysis. (Tentative) D 1357—55t.

Copies are available at 30 cents each from ASTM, 1916 Race St., Philadelphia, Pa.

Los Angeles County is drafting a law requiring approximately 3000 gasoline burning truck and busses in the county to install exhaust afterburners. Cost per vehicle is \$175 to \$200.

Study of air movements by meteorologists in Los Angeles shows that air reaching places where eye irritation and other effects were experienced did not pass near refineries or other heavy industries in a large proportion of the cases. This is said to corroborate evidence that major cause of lachrymators is auto exhaust.

Research Council Sets Single Crystal Study

Reactions on a single crystal of copper in pure water will be studied at the National Bureau of Standards under a grant made available through the Corrosion Research Council of the Engineering Foundation, a project of the American Institute of Mining and Metallurgical Engineers, the Intersociety Corrosion Committee and the Electrochemical Society. A. T. Gwathmey of the University of Virginia will head the advisory committee in charge of the research.

Major attention will be paid to the film of adsorbed layers that forms on the metal when it comes in contact with the water and to the role the film plays in controlling passage of metal cations into the solution.

Many ASTM Papers Deal With Corrosion

Many papers related to corrosion problems and specifically about corrosion reactions are scheduled for presentation during the 59th Annual Meeting of the American Society for Testing Materials June 17-22 at Atlantic City. Included among the papers of interest to corrosion workers are:

Corrosive Fluxes—Their Role in Soldering, R. N. McIntosh, Tin Research Institute, Inc.

Non-Corrosive and Intermediate Fluxes, H. C. Sohl, American Smelting and Refining Co.

Tension-Testing of Plastics, Frank W. Reinhart, National Bureau of Standards.

The following papers are to be presented June 21 beginning at 2 pm:

Corrosion Properties of Chromium-Nickel-Manganese Austenitic Stainless Steels, W. G. Renshaw and R. A. Lula, Allegheny Ludlum Steel Corp.

Fretting Wear of Zircaloy-2 Pellets in High Temperature Water, L. A. Waldman and P. Cohen, Westinghouse Electric Corp.

Intergranular Corrosion Resistance of Low-Carbon Austenitic Chromium-Manganese-Nickel Steels, W. O. Binder, J. Thompson and C. R. Bishop, Electro-Metallurgical Co.

Mechanical Properties of Type 201 Chromium-Nickel-Manganese Stainless Sheet, R. A. Walsh, R. L. Cook and R. A. Lula, Allegheny Ludlum Steel Corp.

Two ASTM Lectures Contain Data of Corrosion Interest

Significant data on corrosion and corrosion protection are included in the Fifth Gillett Memorial Lecture and the 30th Edgar Marburg lecture to be presented during the 59th Annual Meeting, American Society for Testing Materials June 17-22 at Atlantic City.

The third part of the Gillett lecture by D. K. Crampton, Director of Research and Development, Chase Brass and Copper Co., will include a description of new investigations of the fundamentals of corrosion and corrosion resistance of copper and some of the factors affecting the incidence growth of corrosion pits. Title of the lecture is "Structural Chemistry and Metallurgy of Copper."

The future of silicones in selected industries including protective coatings will be covered in the Marburg lecture by C. E. Reed, general manager, Silicone Products Dept., General Electric Co. Title of the lecture is "Industrial Chemistry, Properties and Applications of Silicones."

\$9 Billions for New Water Works Equipment Forecast

Investment of \$9 billions in new equipment and replacement of obsolete structures in the United States water and sewerage plant must be made by 1975 if requirements are to be met. This estimate was made by Water and Sewerage Industry and Utilities Div., Business and Defense Services Adm., U. S. Dept. of Commerce.

BOOK REVIEWS

Treatment of Water for Marine Boilers. Draft British Standard, British Standards Institution, Subcommittee CHE/37/3—Methods of Boiler Water Treatment of Technical Committee CHE/37—Boiler Water Tests. February, 1956. Availability not indicated.

The standard covers treatment of water for marine boilers with drum pressures up to 950 psi. It is designed to permit the engineer to control boiler water treatment under normal working conditions and describes three basic methods of chemical treatment from which a choice can be made according to the type of makeup feed in use. In all cases one or more alkaline reagents are used with or without an organic coagulant.

Extensive recommendations are made covering operation of condensers, treatment of makeup feed, oil contamination, oxygen in feed water, treatment of internal boiler surface after manufacture or repair, care of boilers not in service, scale formation, characteristics of different kinds of water, recommended chemicals, treatment methods, type and frequency of water tests and other matters.

High Temperature Technology. 526 pages, 5 3/4 by 9 inches, cloth. March 15, 1956. Edited by I. E. Campbell. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Per copy \$15.

Contributions on various aspects of the technology related to high temperature by 35 experts in several fields are collected. The book, sponsored by the Electrothermics and Metallurgy Division of The Electrochemical Society, is the outgrowth of several symposia on the subject. In general consideration is given to service at temperature above 1500 C but much material in the materials and methods section discusses processing at moderate temperatures.

Part II, Materials discusses the principal materials available for high temperature service, including metals, oxides, and ceramics. Under the title "methods" discussions include sintering and means of achieving high temperatures, while the last section considers methods of measuring the properties of materials exposed to high temperatures.

An author and subject index are included.

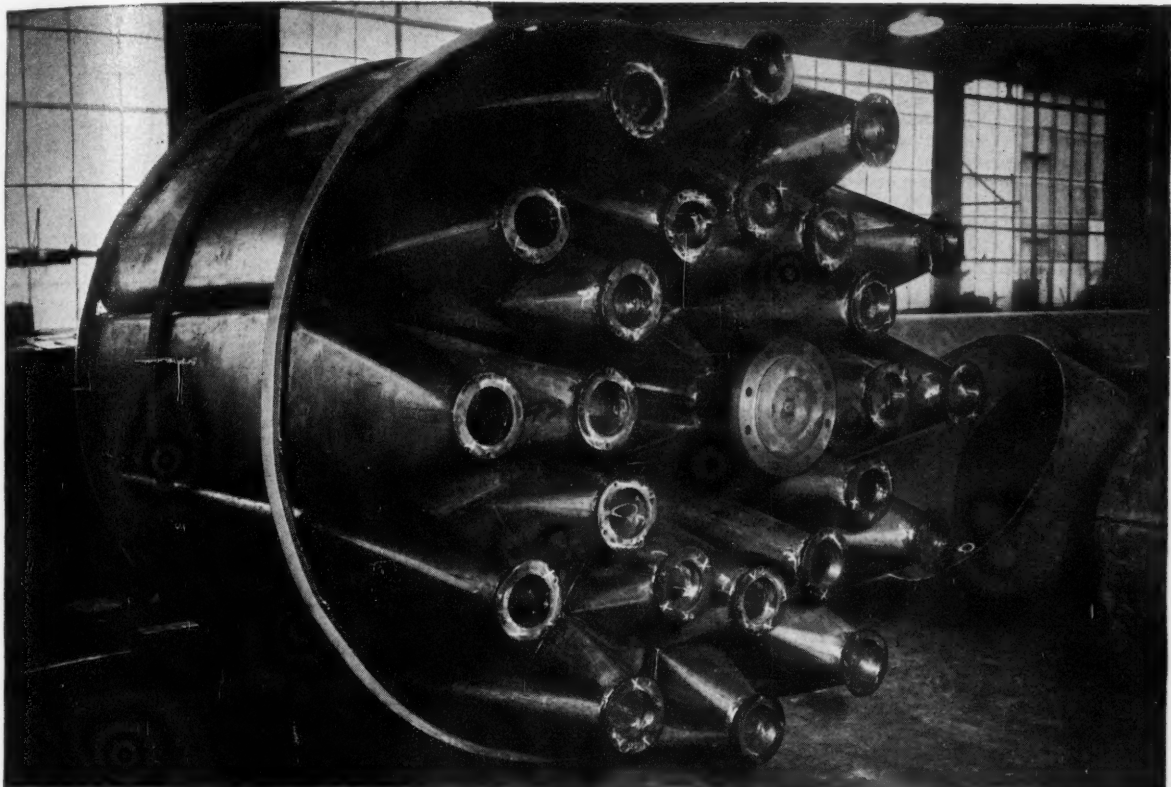
Copper Wire Tables. NBS Circular 31, United States Dept. of Commerce, National Bureau of Standards. January 27, 1956. Government Printing Office, Washington 25, D. C., Price per copy 30 cents.

Data are given on the physical characteristics, including dimensions, analysis, resistance and other criteria for the various kinds of copper wire produced in the United States. Dimensions are given in American, British and metric units.

Physical Metallurgy and Heat Treatment of Titanium Alloys. 60 pages, 6 x 9 inches, cloth. 1955. Richard J. McClintock, G. William Bauer and Lee S. Busch. The Mallory-Sharon Titanium Corp., Niles, Ohio. Per Copy \$1.

This monograph relates to the character-

(Continued on Page 100)



Hot magnesium-carbonate slurry presents no corrosion problem when handled by the unit shown here. Made of chromium-nickel stainless steel throughout, this 24-

duct indexing hopper for a manufacturer of pipe insulation is an example of all stainless process equipment fabricated by Stainless Products, Inc., Jersey City, N. J.

Chromium-nickel stainless frees hopper from trouble facing many process units

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As in other processing units, corrosion of an indexing hopper endangers product purity, inflicts expense for maintenance or repair and stops output during the downtime.

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In addition, the high mechanical properties of stainless steels allow designers to cut bulk and deadweight without sacrificing strength or safety of process equipment.

Fortified with Nickel, these steels withstand impact and battering,

abrasion and erosion. They resist creep and oxidation at elevated temperatures, and retain high strength, toughness and freedom from "notch" effects, to below -400°F.

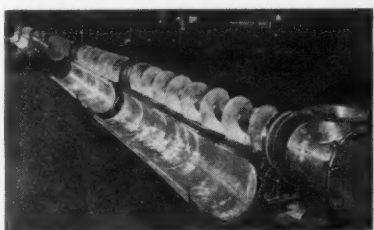
Easy to clean and keep clean, chromium-nickel stainless steels are sanitary metals that minimize maintenance.

Readily fabricated

Fabricators draw, spin, forge and solder stainless. They punch, shear, bend and weld this versatile material. Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. So investigate use of stainless steel equipment.

Whenever your difficulty is due to metal failure, send us the details. We'll give you suggestions on how to dispose of it. Write for List "A"

of available publications. It contains a simple form that makes it easy for you to outline your problem. Send for it now.



Conveying abrasive phenolic powder calls for high resistance to wear. That's why stainless steel is used for this Archimedes conveyor, 50' long and 14" in diameter. Screw and housing tube, welded together, rotate as a unit. Design allows easier, faster cleaning, no matter what the color of resin handled. Fabricated by Stainless Products, Inc.



THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

BOOK REVIEWS

(Continued From Page 98)

eristics of titanium and titanium alloys produced by the vacuum double melting Method S which assures alloy segregation and permits holding carbon and gaseous contaminants to very low limits. Five grades are considered. Data presented are based on an investigation carried out under a Navy contract.

The introduction covers nomenclature of phases, classification, interstitial impurities and other matters. The second part pertains to hardening theories while the third covers annealing. Hardening data include discussions relating to alpha alloys, martensitic type alloys and metastable beta alloys.

Forty-two references and a subject index are included.

Wrought Iron. Third Edition. 102 pages,

6 x 9, cloth, 1956. By James Aston and Edward B. Story. A. M. Byers Co., Pittsburgh, Pa. Per Copy, \$1.

A comprehensive exposition of wrought iron materials. Chemical and structural characteristics are followed by a brief history of wrought iron production prior to 1850. Modern developments in production are discussed as are quality standards, specifications for durability testing, methods of working, fastening

(Continued on Page 101)

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BOOK REVIEWS

(Continued From Page 100)

and welding, and principal applications. In the chapter devoted to characteristics the resistance to corrosion of wrought iron is laid to the character of the layer of corrosion products formed on the surface, the effect of the slag fibers and its ability to form a firm bond with metallic and organic coatings.

Bibliography of Solid Adsorbents, 1943 to 1955. 1528 pages, 7 3/4 x 10 3/4 inches, cloth. March 1, 1956. National Bureau of Standards Circular 566. Victor R. Dietz, U. S. Government Printing Office, Washington 25, D. C., Per copy, \$8.75.

An annotated bibliographical survey of scientific literature relating to solid adsorbents. The coverage of the volume is restricted to heterogeneous phenomena at solid-liquid and solid-gas interfaces. The abstracts are organized into chapters headed, adsorption of gases and vapors on solid adsorbents, adsorption from solutions on solid adsorbents, thermal effects in adsorption process, theories of adsorption, general information on adsorbents and special methods of investigation, preparation of adsorbents, among others.

Also included are: A list of commercial solid adsorbents, an author index and a subject index of 89 pages.

Lectures on the Electrochemistry of Corrosion. In French. Technical Report No. 30. 42 pages, 8 1/4 x 11 3/4, paper. February 22, 1956. M. Pourbaix, Centre Belge d'Etude de la Corrosion, 21 Rue des Drapiers, Brussels, Belgium. Price, 250 francs.

These provisional notes on lectures given at the University of Brussels are limited essentially to a report on the results of original work done after 1934 and which concern the electrochemical and corrosion reactions of metals. The lectures cover the following points, among others: Economical and technical considerations, scientific considerations, chemical and electrochemical reactions, chemical equilibria, electrochemical equilibria, electrochemical kinetics, corrosion and protection of iron and its alloys. Numerous diagrams are included.

Electrochemical Behavior of Uranium. Equilibrium Diagrams Tension-pH of the System U-H₂ at 25 C. In French. Technical Report 31. 14 pages, 8 1/4 x 11 3/4, cloth. February, 1956. E. Deltonbe, N. de Zoubov, and M. Pourbaix. Centre Belge d'Etude de la Corrosion, 21 Rue des Drapiers, Brussels, Belg. Price, 70 francs.

The following are included: Free enthalpies of the standard formation at 25 C, reactions and equilibrium formulae, equilibrium diagrams of tension-pH and interpretation.

Corrosion Protection With Aluminum Coatings. Part 3. (In Dutch) 58 pages, 8 1/4 x 11 3/4 inches, paper. February, 1956. E. M. J. Mulders, W. G. R. de Jager, J. W. Boon. Metaalinstuut TNO, Delft, Holland. Price, 2 francs.

This is Part 3 of the institute's series of reports on the laboratory testing of aluminum and aluminum coated steel. Results of test series 4 and 5 and of one of the sixth proof series are reported. Data are given on physical changes and weight losses of materials submerged in water. Galvanic action between aluminum, steel, zinc-coated steel are tabulated.

Five regional NACE meetings will be held during the fall of 1956.

Topical Indices to the material published in the Technical Section of Corrosion are published annually in the December issue.

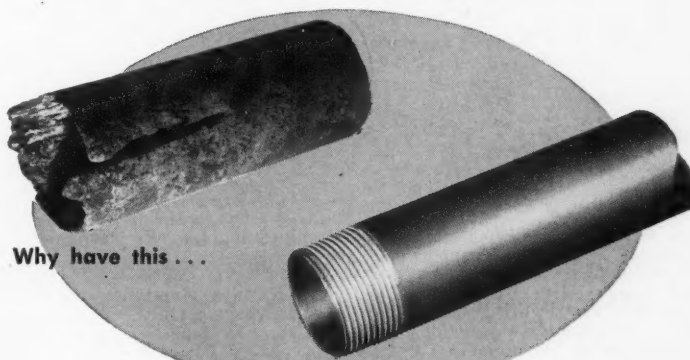
Silicone Resin Paint Is Reported Good at 1400 F

A ceramic frit, silicone resin type paint capable of withstanding temperatures up to 1400 F without significant deterioration or loss of protective properties is described in a report (PB 111957 "Development of Heat-Resistant Paint," M. Kornbluth, Corps of Engineers, U. S. Army. \$4 per copy, OTS, U. S. Dept. of Commerce, Washington 25, D. C.) recently issued.

The paint was developed by the army after tests of existing paints proved inadequate to reduce accelerated oxidation and rapid destruction of steel components such as automobile mufflers and manifolds.

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NEW PRODUCTS

Materials Literature

Harry Miller Corp. is the new name of Haas Miller Corp., chemical manufacturing firm at 4th and Bristol St., Philadelphia 40, Pa. Among the industrial chemicals manufactured are synthetic lubricants, solvents and rust preventives.

Niphos Process was used in coating with nickel alloy a standard section of heating coils in the No. 3 centerline cargo tank of the S. S. Bulk Star, used in transporting sour crude and salt water ballast between Arabia and England. After a year's test it was estimated the life of the pipes had been extended to many years. Formerly the life of these coils without repair was about six months. The process is available on license from Niphos Process Sales Corp., 19 Rector St., New York City.

Unichrome Super 5300, a sprayable plastisol paint can be applied in thicknesses of 50 to 60 mils per spray coat, triple previously possible thicknesses, according to Electroplating and Coatings Div., Metal and Thermit Corp., 100 Park Ave., New York 17, N. Y. Gun application of full solids content vinyl plastisols without diluent is now possible, making "sheet" applications on tanks, ducts and other large equipment feasible. The coating has good abrasion, acoustical and electrical characteristics.

Bart Manufacturing Corp. and Bart Laboratories Co., Inc., both of Belleville, N. J. have been consolidated into a corporation named Bart Manufacturing Corp. Bart Laboratories will be a division of the new company.

Chromic Acid solutions typical of chromium plating and copper stripping can be relieved of their contaminations by a patented process developed by Mutual Chemical Division, Allied Chemical & Dye Corp. The process is available without formal license. It involves ion exchange treatment to remove metallic contaminants.

Cathodic Protection current can be generated by a new device patented by Corrosion Rectifying Company of Houston for attachment to pump housings on oil wells. The generator runs off the pumpings unit, eliminating the need to purchase current and rectify it. It is designed for installations protecting oil well casing underground.

Stainless Steel honeycomb structures of substantially the same weight per volume as aluminum honeycombs are being manufactured by American Silver Co., Inc., 36-07 Prince St., Flushing 54, N. Y.

Refractory Molybdenum Borides, a 6-page bulletin describing applications, physical and mechanical properties is available from Climax Molybdenum Co., 500 Fifth Ave., New York 36, N. Y. Four borides and seven multi-boride systems are described. The materials have high resistance to corrosion and abrasion among other things.

Teflon "spaghetti" tubing for use in in-

struments is available from Pennsylvania Fluorocarbon Co., 1115 N. 38th St., Philadelphia 4, Pa.

DeVilbiss portable paint heater, made by De Vilbiss Co., Toledo, Ohio, is designed to permit application of heavier coats while saving material because of the reduction in overspray and fog. Application of films by heater produces better films, the company claims. They are made with three or six kilowatt heaters, the larger capacity machine designed for use with more than one spray gun.

Gallium is being used as a sealant in joints and valves of glass laboratory equipment. This use was developed at the East St. Louis, Ill. works of Aluminum Company of America.

Zirconium production of the Carborundum Company will be increased to over 1.5 million pounds yearly when a new plant at Parkersburg, West Virginia is completed. AEC has awarded a contract to Carborundum to supply an additional 500,000 pounds of the metal yearly. It presently is producing 325,000 pounds and has given AEC a priority on an additional 400,000 pounds yearly.

Dexter-Conde bronze pump, is made by the Dexter Folder Company, Pearl River, N. Y. in three models with capacities ranging from 3.5 to 33 cfm and maximum continuous pressure to 20 psi. The bronze pump has vanes of sintered carbon, eliminating the need for lubrication, two lifetime grease packed ball bearings and no seals or gaskets. It is designed to pump for vacuum or pressure in handling steam, natural or manufactured gas, nitrogen or other inert gases carrying entrained moisture. The unit is non-sparking.

Van de Graaf accelerators of one and two million volts respectively will be constructed for x-ray examination of pressure vessels at the Chicago Bridge and Iron Company Birmingham, Ala. plant. High Voltage Engineering Corp., 7 University Road, Cambridge 38, Mass. will build them.

Production is expected to get under way in the last quarter of 1956 at the American Brass Company's \$15,000,000 brass mill at Los Angeles now under construction.

Electronic control systems can be devised by interconnection of 21 standard modular units which are inexpensively mass produced at savings up to two-thirds of the cost of custom built units. The units can be connected by plug-in units which can be expanded or regrouped by semi-specialist personnel and use a single standard communications channel. Five standard control systems now available using the modular units are designed as automatic alarms, remote metering, discrete control, proportional control and transmission systems. The units, made by Sparton Control Systems Division, The Sparks-Withing-

ton Co., are designed to function by remote control over telephone, telegraph, microwave or other signal channels.

Data and Directions for Electroplating With Rhodium, a 20-page booklet available from Baker & Co., Inc., 113 Astor St., Newark 5, N. J., is designed to help electroplaters and products designers. Many charts of tabulated information are included.

Profilum, a precipitated silicon coating containing neither oils nor plasticizers but which can be applied by conventional spray equipment is supplied in grades for air drying or baking. Allied Porcelain, Inc., Profilum Division, 851 Market St., Waukegan, Ill., manufacturers, claims the coating has excellent abrasion resistance, good adhesion over virtually any coatable surface and excellent resistance to a wide range of chemical environments. Its quick drying characteristics makes it possible to spray from scaffolding without danger of damage to nearby surfaces. The coating becomes touch dry in a few minutes. Application of the Profilum system to a new galvanized industrial building was demonstrated April 27-28 at the Houston Plant of Clemtex, Inc.

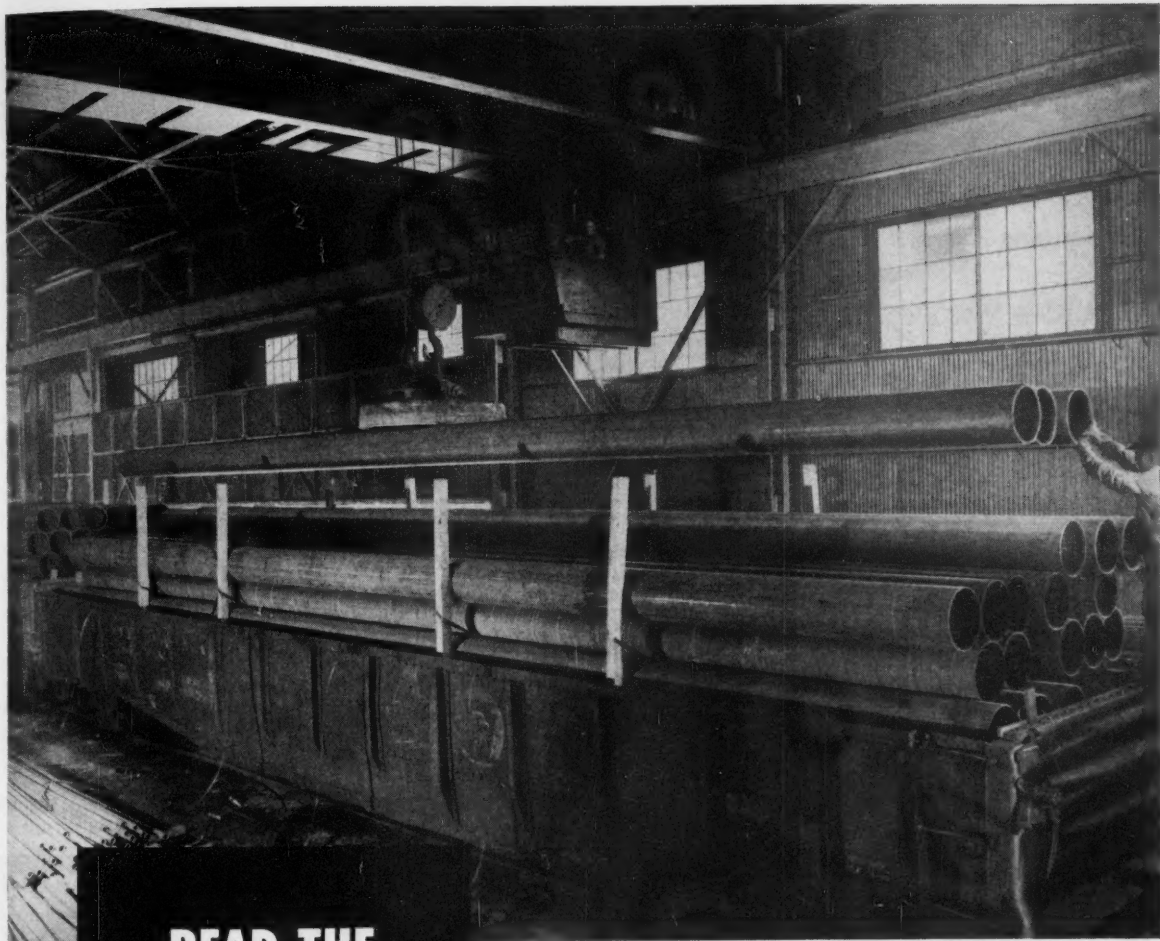
All-Coat Engineered Coating Systems are based on data gathered during a 10-year statistical study of corrosive environments. Selection is by summation of factors affecting the cost of a coating system including chemical resistance, surface preparation, thickness, labor, aging properties, coverage, cost and adhesion. All-Coat Engineered Coating Systems, 1421 Norman, St. Louis 22, Mo. originated the method.

Pure Silver can be integrated into aluminum surfaces by a new method which eliminates bridging of oxide or other films often encountered when aluminum is electroplated. The process results in the replacement of surface layer aluminum crystals with those of silver. R. B. Goody, engineer for Eastern Switchgear Division, Federal Pacific Electric Co., Scranton, Pa. says the process consists of carefully cleaning aluminum surfaces, controlled deposition of special oxides, replacement of oxides with an intermediate deposition of zinc and then displacement of the zinc by silver. Coated aluminum is expected to find extensive use in electrical conductors, and at points where aluminum conductors are connected to copper alloy materials.

Dearborn Chemical Co., Chicago has been named exclusive sales agents to the petroleum industry for a line of fatty acid nitrogen compounds. They are designed to control corrosion and bacteria in petroleum production and refinery operations. The line includes fatty amines, fatty amine salts and fatty quaternary ammonium compounds used in injection flood water and in preparation of oil phase corrosion inhibitors.

Polyglas, a structural plastic resistant to

(Continued on Page 104)



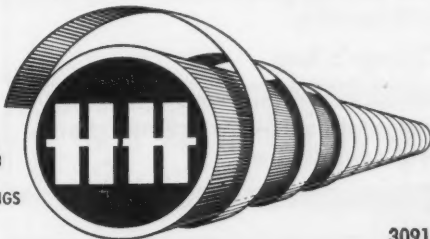
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NEW PRODUCTS

(Continued From Page 102)

acids, alkalis and other corrosives is described in a Bulletin No. 56 available from Modular Plastic Corp., 1635 Westminster, Detroit 11, Mich.

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Graduate Metallurgical or Chemical Engineer with minimum 7 years' work experience which should include analysis and resolving of corrosion problems related to petroleum producing and refining materials and equipment plus steam boilers and other auxiliary equipment.

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Stauffer Chemical Co. will build a fourth sulfuric acid plant at Dominquez, Cal. with full scale production scheduled

early in 1957. It has three plants in the state already.

Andrex, Isovolt 400 KV Mobile Constant Potential X-Ray, equal in capacity to million volt x-ray machines are made by Holger Andreason, Inc., 703 Market St., San Francisco 3, Cal. Rays from the machine can penetrate 1/2 inches of steel.

Alcoa Research Laboratories is the new name for Aluminum Research Laboratories.

PSC (Permanent Single Coatings) a material of unspecified analysis, when deposited on a metal surface will protect it against soft abrasives, frequent washing and handling, most saline solutions, dilute acids, many strong alkalis, organic solvents, foodstuffs, beverages, humidity, gases normally in air and many sulfur compounds, according to PSC Inc., 303 Fifth Ave., New York, N. Y. Metal can be stamped or otherwise shaped without removing or damaging the coating, manufacturers say.

Tube Turns wrought iron welding fittings and flanges are described in a folder available from Tube Turns, Inc., 224 East Broadway, Louisville, Ky.

Impervite "cross-bore" heat exchangers are recommended for use handling corrosives, except a few highly oxidizing agents by John Reys, Chief Engineer, Falls Industries, Inc., Aurora Road, Solon, Ohio.

Titeflex, Inc., Springfield, Mass. is manufacturing (Continued on Page 105)

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NEW PRODUCTS

(Continued From Page 104)

Manufacturing a new lightweight, low-cost metal tubing designated "Titeflex 500." The tubing, made by a patented European process which winds a thin strip of metal into a tube of the desired diameter, with smooth bore on the inside and helical ridges on the outside, has high resistance to crushing forces. When made of lead coated steel strip it is suitable for corrosive environments.

Rivichlor, a high strength polyvinyl chloride pipe, is said to have impact strength as high as 2.5 Izod and to remain tough and non-brittle even at sub-zero temperatures. It is available in standard or extra heavy wall construction, schedules 40 and 80 IPS. Working pressure of the 12-inch extra heavy pipe is reported to be 490 psi and of the 2-inch extra heavy pipe 255 psi at 70 F by fabricators, American Hard Rubber Co., 93 Worth St., New York 13, N. Y. Diaphragm valves are available.

Chlor-Caustic facilities of Pennsylvania Salt Manufacturing Co., Calvert City, Ky. will be increased by a new plant scheduled to be completed during 1957.

Stauffer Chemical Company plans to spend a million dollars expanding and modernizing its Niagara Falls, N. Y. plant.

Miley-Monsanto-Sonneborn Process, an acid-sludge decomposition process will be marketed by Monsanto Chemical Co. Invented by chemist Hunter Miley of Sonneborn, the disposal technique permits recovery of practically all sulfuric acid present in sludge. It also converts the organic portion of the sludge into coke suitable for use by the chemical industry. It will permit petroleum refiners and manufacturing chemists to dispose of acid sludges without dumping into water or pooling. The process involves mixing the sludge with hot coke, where the gas is converted into a gas of high sulfur dioxide concentration while the organic matter is converted into more coke.

Silicones Division, Union Carbide and Carbon Corp., has opened several units of its Long Reach, West Virginia plant.

Gas Lines of its own are seen by Southern California Edison Company as the only solution to its need for more power and to simultaneously reduce the volume of pollutants emitted by its plants. The company has asked the California Public Utilities Commission to direct gas companies to provide transportation for gas it needs. The company would turn over to the companies supplies of gas it might purchase or acquire.

Ets-Hokin & Galvan, San Francisco has been named a distributor of magnesium anodes by The Dow Chemical Company. The new distributor will concentrate on cathodic protection of ship hulls in the Pacific trade.

Ferro-Pak bags, impregnated with vapor phase inhibitor are supplied by Cromwell Paper Co., 4801-39 S. Whipple St., Chicago 32, Ill. to American Type

(Continued on Page 106)

before you buy or specify
protective coatings
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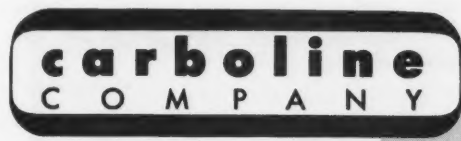


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NEW PRODUCTS

(Continued from Page 105)

Founders to be used in shipping printing presses. After light oiling the presses are enclosed in the bags. Saving in setup time on delivery has been reduced from 6 to 8 hours to one hour.

Dynel overlays improve the resistance of low pressure glass laminates to chemicals and abrasion, according to Textile Fibers Dept., Carbide and Carbon Chemicals Co., a division of Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y. A. L. Snyder, sales manager of the department says they can be used with polyesters, phenolics

or epoxy laminates. A copolymer of vinyl chloride and acrylonitrile, Dynel's resistance is of value in protecting the other resins in the laminate from attack. Numerous other advantages are claimed.

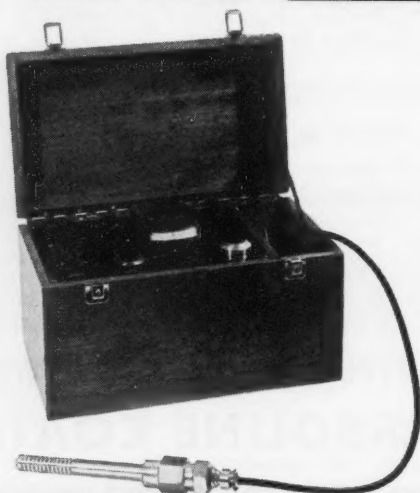
Reactor Grade Zirconium sponge will be produced by July, 1957 at the rate of 1.5 million pounds a year at a multi-million dollar plant at Ashtabula, Ohio. The sponge will sell for \$7 a pound to commercial users. The process to be used in the plant is based on new techniques developed at Cincinnati Research Division of National Distillers Products Corp., a division of U. S. Industrial Chemicals Co. Sodium is used as a liquid in the process, giving a product higher in purity than when magnesium is used, according to the company. Haf-

nium-free zirconium has extremely high resistance to most corrosives and heat.

Fernicklon nickel-plated steel wire with up to 10 percent nickel coat is being produced now by National-Standard Company, Niles, Mich. It is produced by the improved Kenmore process.

Inconel 700, age-hardenable nickel-cobalt-chromium alloy, and Incoloy 901 high temperature alloys have been developed for use at high temperatures found in turbines. Inconel 700 has adequate strength to be forged into turbine blades for use at temperatures up to 1650 F, approximately 150 F higher than Inconel X. Now available in rods, a small volume of cold rolled sheet has been produced experimentally. Inconel 901 is for use in aircraft and industrial gas turbines from 1000 to 1400 F.

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MEN in the NEWS

Daniel E. Lehane is the new manager of sales engineering for The Chromalloy Corp., 450 Tarrytown Road, White Plains, N. Y.

Albert H. Cooper has joined American Hard Rubber Company as assistant to the director of research and development. He is an authority on organic and inorganic chemicals.

Allen B. Norton, general manager of Aluminum Company of America's castings divisions has retired after more than 42 years service.

Robert B. Taggart is now manager of manufacturing of the Aurora Pump Division, The New York Air Brake Company.

C. D. Cobbett received a watch February 9 as an award for 25 years' service with Hill, Hubbell Company of Cleveland. Milt Bowen, vice-president and general manager made the presentation.

John R. Roberts, sales manager of Quelcor Inc. has been elected to the firm's board of directors.

Fred P. Demme has been named manager of market development for Sharples Chemical Div., Pennsylvania Salt Mfg. Co.

Charles Bueltman has been promoted to the post of manager, Industrial Waste Treatment Dept., The Permutit Co., 330 West 42nd St., New York 36, N. Y.

Spencer & Partners, 19 Grosvenor Place, London S. W. 1, specializing in corrosion prevention, especially in design of cathodic protection installations has been formed as independent consulting engineers by K. A. Spencer with a partner, P. W. Heselgrave. W. H. J. Vernon is associated with the firm as consultant and adviser.

Max E. Bretschger has retired as president of Becco Chemical Division, Food Machinery and Chemical Corp. on his thirtieth anniversary with the company. He will continue to act as senior technical adviser. **Frederick A. Gilbert** will succeed Dr. Bretschger.

(Continued on Page 108)

McAlester News

1956

ASSOCIATED PRESS

Gas Company Will Start Big Project Monday

**Forty-Man Crew
Will be Employed
In McAlester Area**

Consolidated Gas Utilities Corporation will get started Monday on a major project involving a survey of all distribution lines and installation of magnesium anodes where it is found necessary to arrest pipe corrosion.

The work will require about four months and will provide employment for a crew of about 40 men at the peak of the program, which will represent an overall expenditure of approximately \$175,000.

The job has been contracted to Cathodic Protection Service Company, Houston, Tex., which will be in complete charge of the project. Headquarters will be established at the Consolidated warehouse on West Harrison, just off of North Main.

Portions of some streets may be temporarily barricaded in



LITTLE TROUBLE — Marilyn Monroe smiles over her shoulder after strap of her dress broke during press conference in New York. Strap was apparently held in place originally by safety pin which can be seen dangling from end of strap. The blonde actress announced she planned to make movie with Sir Laurence Olivier (NEA Telephoto).



**A RECENT STORY
ON THE FRONT
PAGE OF THE
McALESTER NEWS
CAPITAL, McAlester
Okla.**

Through the refinement of known techniques, CPS engineers in charge of the project described in the adjacent news item are not only locating "hot spots" on the gas distribution system for the subsequent application of cathodic protection with magnesium anodes, but they are also pin-pointing the areas where replacements of or repairs to the piping are necessary due to the advanced stage to which corrosion has progressed.

Why delay your protection program longer? Call on Cathodic Protection Service's large staff of experienced corrosion engineers to complete **NOW** work you have projected one, two or even more years into the future.

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In The Field of Cathodic Protection**



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Wahlquist Pipe Locators
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Homco and Barado and Page Backfills
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Everything in the cathodic protection field . . .
from an insulating washer to a turnkey contract installation.

MEN in the NEWS

(Continued From Page 106)

Maurice Van Loo, director of paint research for Sherwin-Williams Company has been selected to present the annual Joseph J. Mattiello Memorial Lecture at the 34th Annual Meeting of the Federation of Paint and Varnish Production Clubs to be held October 22-24 at the Netherland Plaza Hotel, Cincinnati.

Robert T. Atkins has been made sales representative of Standard Magnesium Corp., Tulsa in the Chicago area.

Edward M. Welty has been appointed Eastern District Manager for the H. M. Harper Company, Morton Grove, Ill.

John Thomas Reid has been named research manager of the American Society of Mechanical Engineers.

Peter B. Gordon has been designated to receive the 1956 Distinguished Service Award of the Heating, Piping and Air Conditioning Contractors National Association. He is vice-president of the firm of Wolff & Munier, Inc., New York City and has served as chairman of the association's radiant heating panel committee since 1946.

Wayne Kincannon is new plant manager of Stauffer Chemical Company's North Little Rock, Ark. installation. He formerly was with Stauffer at Lubbock, Texas.

Ralph H. Clark has been appointed to

the position of supervisor, Stainless Steel Fabricating Dept., Portland Copper and Tank Works, Inc., South Portland, Me.

C. H. Raab has been named chief metallurgist of American Chain Division, American Chain and Cable Co., Inc., York, Pa.

Ralph T. Beasley is now district products representative for alloy, stainless and tubing sales for the U. S. Steel Supply Division of U. S. Steel, with headquarters in Houston. He formerly was at San Antonio.

Waldo Shumway, provost of Stevens Institute of Technology, Hoboken and secretary of the board of trustees died March 8.

R. T. Whitzel has been named general production manager and **John D. Harper** general manager of the smelting division of Aluminum Company of America.

H. F. Jorgensen has been elected president of John N. Thorp Co., Inc., 78-80 Middagh St., Brooklyn.

Robert J. Bricmont has been named manager of the engineering service department, A. M. Byers Co., Pittsburgh.

Thomas W. Clapper has been appointed associate director of research for American Potash and Chemical Corp. to head research activities at the company's Henderson, Nev. plant. He formerly was with Chemical Construction Company at Garfield, Utah.

Wesley C. L. Hemeon will become director of the firm to be known as Hemeon Associates, organized for general consultation in air pollution problems. The firm's offices will be at 121 Meyran Ave., Pittsburgh.

Louis F. Frazza, Hawthorne, N. J. an executive of Johns-Manville Sales Corp. has been appointed director of the Water and Sewerage Industry and Utilities Division, Business and Defense Services Administration, U. S. Dept. of Commerce.

John G. Thompson, chief of the metallurgy division, National Bureau of Standards has retired after more than 35 years of government service. He was appointed assistant chief of the division in 1942 and chief in 1946. He has made contributions in research pertaining to the preparation of pure metals, evaluation of properties, gases in metals, special refractories, corrosion and powder metallurgy and is author of more than 35 technical publications. Among other achievements he was successful in 1938 in producing iron of 99.99 percent purity, highest established purity to that time.

B. E. Anderson is new chief engineer of Federated Metals Division, American Smelting and Refining Co. His headquarters will be at Salt Lake City, Utah.

Edmund A. J. Mroz, 17 Harrison St., Melrose, Mass. will be sales and service engineer in the Northeast for The Carboline Company, St. Louis.

Thomas E. Deger has the position of director of organic research for the Pennsylvania Salt Manufacturing Co.

(Continued on Page 110)

ADD 10 YEARS LIFE TO YOUR WELL CASING WITH VIBRA-PAK ANODES



You can't afford to be without this protection a day longer! Right now corrosion is eating away your well casing . . . before long, expensive repair and replacement will be necessary.

This corrosion can be stopped by installing VIBRA-PAK anodes. Think of the savings this will mean!

Vibra-Pak anodes are best because they are designed and made to combat the specific corrosive conditions of the soil around your well. Vibra-Pak anodes are spectrographically analyzed to assure exact specifications, they have a thin, solidly banded spiral core to assure longer life and their exclusive backfill material means more efficient operation.

Our engineers will survey your wells, take soil resistivity tests and make recommendations . . . all without obligation.

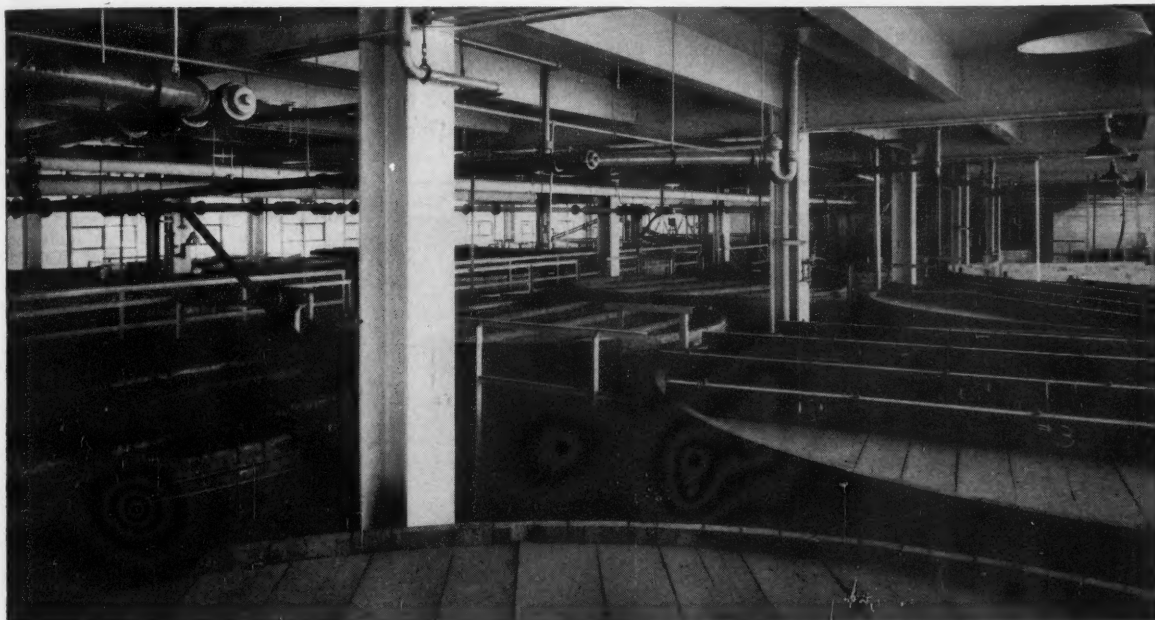


Standard Magnesium Corporation

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Parlon® Stays On

Meets Challenge of Chemicals



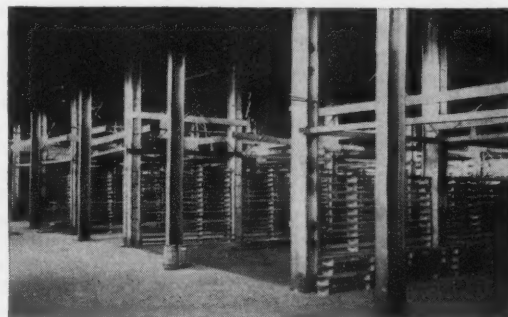
IN A VINEGAR PLANT—To protect a new vinegar-manufacturing building against the corrosive fumes of acetic acid, the interior of this plant was finished with Parlon-based Rigortex, a product of Inertol Co., Inc., Newark, N. J.

No matter how strong the corrosive challenge—whether it comes from acid, alkali or the elements—Parlon-based protective coatings are providing longer protection at lower long-term cost.

Easy to apply and quick drying, Parlon-based chlorinated rubber paints have proven themselves in actual use where other finishes have failed to provide satisfactory service. That's why—for those hard-to-protect surfaces—more and more maintenance people are turning to Parlon finishes to solve their protective coating problems.

No matter how difficult your maintenance paint requirements, chances are there's a Parlon-based coating that will meet them. For full technical data on Parlon, call or write your regular supplier of quality paint finishes or write directly to Hercules.

... AND A FERTILIZER BUILDING—The steel structures of this fertilizer mixing building are continually under attack from ammonia gas, nitric acid fumes, compounds containing free sulphuric acid and free phosphoric acid. To meet this challenge, Parlon-based Torex, another Inertol Co. product, was selected.



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PARLON (CHLORINATED RUBBER) PAINTS ARE AVAILABLE FROM 400 MANUFACTURERS UNDER THEIR OWN BRAND NAMES

CR56-4

MEN in the NEWS

(Continued from Page 108)

J. H. Abrams will be head of newly acquired office and plant facilities of American Chemical Paint Co. at St. Joseph, Mo.

George W. Howard has been promoted to fill the newly-created position of technical director at the Corps of Engineers' Research and Development Laboratories, Fort Belvoir, Va. He will be assistant to the director.

Gregory Gould has been appointed to the administrative engineering staff of Water Service Laboratories, Inc.

Gerald J. Bayern has joined Barrett Division, Allied Chemical & Dye Corp. as marketing and economic analyst.

Thomas J. Henry, formerly national sales manager of The Glidden Company has been elected vice-president in charge of sales for the Vortex Manufacturing Co., 1978 West 77th St., Cleveland 2, Ohio.

W. A. Wesley of The International Nickel Co., Inc., delivered the Hotherhall Memorial Lecture at Blackpool, England April 19. He reviewed research efforts to improve nickel coatings and reduce their cost.

Tod Pazdral, Jim Ford, Dick McHenry, Jack Duke and Jack Pelkey, all of Tod

Pazdral Pipeline Specialties, Houston; **Don Corp and Ken Cusick**, of James S. Kone & Co., Amarillo; **Jack Stout**, Canadian Equipment Sales & Service Co., Ltd., Edmonton, Alberta, Canada attended a refresher course at the Tulsa plant of T. D. Williamson, Inc.

Robert J. Anderson is the new director of research and development for Diamond Metal Co., Houston. He formerly was head, department of metallurgy, Southwest Research Institute, San Antonio.

John H. Caldwell has joined Pittsburgh Coke & Chemical Company as a salesman in the firm's protective coatings division. He will handle the company's products in the Gulf states area. Formerly with S. D. Day Co., Houston, he is an NACE member.

George McCoy has been named manager of Pennsylvania Salt Manufacturing Company's research and development department.

Dana Barker, formerly with General Tire and Rubber Co., will have headquarters in the Cleveland office of Reilly Tar & Chemical Corp. where he is sales engineer.

Herbert C. Vacher, head of the metallographic and x-ray diffraction laboratory at the National Bureau of Standards has been awarded the Department of Commerce Silver Medal for meritorious service for his contributions in the field of metallurgy. He has been a staff member for 30 years.

Wendell P. McKown, Jr., has been elected vice-president Manufacturing of Cooper Alloy Corp., Hillside, N. J.

Hans P. R. Frederikse, a Fulbright scholar has been appointed chief of the Solid State Physics Section of the Atomic and Radiation Physics Division at the National Bureau of Standards.

A. P. Gagnebin has been appointed manager and **Harold Larsen**, assistant manager of the Nickel Sales Dept., The International Nickel Co., Inc.

William J. Flaherty and John M. McGovern are newly assigned market development specialists in the Merchandise Department of Polyken Sales Division of The Kendall Company. Mr. Flaherty will continue to work out of Philadelphia while Mr. McGovern will have Tulsa as headquarters.

Harry N. Huntzicker has been appointed executive vice-president of The American-Marietta Company.

AICHe Meetings Scheduled

Meetings of the American Institute of Chemical Engineers have been scheduled as follows:

Sept. 9-12—Pittsburgh, Pa. Wm. Penn Hotel.

December 9-12—Boston, Mass. Statler Hotel, annual meeting.

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CORROSION ABSTRACTS

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2. TESTING

2.3 Laboratory Methods and Tests

2.3.2

In Corrosion Testing, Humidity Cabinets Don't Tell the Whole Story. LOUIS SCHLOSSBERG. *Steel*, 135, No. 2, 114-116, 118 (1954).

In an account of comparisons made between field tests and tests in laboratory humidity cabinets for measuring the corrosion-resistance (mainly of steels), a useful list, with descriptions, is given of 15 different American and British test procedures for accelerated corrosion testing of metals.—MA. 9329

2.3.2, 6.3.6, 4.4.7

Report of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. [Corrosion Tests on Copper Strip]. Am. Soc. Testing Materials, Preprint No. 33, 1954, 78-82.

Describes a tentative method of testing for detecting any corrosive action on copper of aviation and automotive gasoline, fuel oil, cleaners (Stoddard), solvent, etc. A polished copper strip is immersed in a given quantity of sample and heated at a temperature and for a time characteristic of the fluid being tested.

At the end of the test period the surface of the strip is compared with the A.S.T.M. Copper Strip Corrosion Standards. For volatile fuels, a stainless steel bomb is used.—MA. 9363

2.3.4

Contribution to the Direct Determination of Combined Oxygen in Metals, and Metal Oxides. II. Determination of Oxide Content of Metal Oxides. (In German.) E. EBERIUS AND W. KOWALSKI. *Ersmetall*, 7, No. 8, 339-343 (1954) Aug.

Combined oxygen in oxides and carbonates by solution in hydrochloric acid/acetic acid, and ultimate determination of the water formed with the Karl-Fischer reagent. Detailed discussion of application to numerous oxides and carbonates. Method is said to have been applied to determination of oxides in metal powders, ores, roasted pyrites and blends, slags, leach slimes and pigments (e.g., lithopones).—BNF. 9491

2.3.4, 1.6

Rapid Detection of Cations. G. CHARLOT, D. BEZIER AND R. GAUGUIN. Book, 1954, 92 pp. Chemical Publishing Co. Inc., 212 Fifth Avenue, New York, N. Y.

Translation of the latest edition of a French book first published in 1943. After notes on advantages of the method, apparatus, and preliminary tests, gives spot tests for 35 metals, ammonium and phosphate ions. Separations are kept to a minimum.—BNF. 9578

2.3.4, 2.3.2

Methods of Testing and Checking in the Field of Metal Corrosion. (In Ital-

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ALL—The Abstract Bulletin, Aluminium Laboratories, Ltd. P. O. Box 84, Kingston, Ontario.

ATS—Associated Technical Services Abstracts, Associated Technical Services, P. O. Box 271, East Orange, N. J.

AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.

CBEC—Centre Belge d'Etude de la Corrosion (CEBELCOR), 17 rue des Drapiers, Brussels, Belgium.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

EL—Electroplating. 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.

IIM—Transactions, The Indian Institute of Metals, 23-B, Netaji Subhas Road, P. O. Box 737, Calcutta, India.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum. 26 Portland Place, London W-1, England.

JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chrome Nakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana, Associazione Italiana di Metallurgia. Via S. Paolo, 10, Milano, Italia.

MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

SE—Stahl Und Eisen, Verlag Stahlisen, M. B. H., Dusseldorf, August-Thyssen Str. 1. Postcheck Koln 4110, (22a) Dusseldorf, Germany.

TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association, 34 Berkeley Square, London W.1.

ian) G. BIANCHI. *Metallurgia italiana*, **46**, special supplement to No. 5, 109-112 (1954) May.

Testing by immersion in static solutions, immersion in agitated and aerated solutions, saline fog and by alternating immersion. Two references.—BTR. 9336

2.3.4, 3.7.3, 6.2.5

Corrosion Tests on Welded Austenitic Stainless Steel. (In Dutch). A. PH. KRIJFF AND A. DE VISSER. *Smit Mededelingen*, **9**, No. 3, 79-87 (1954) July-Sept.

Influence of plate material properties and plate thickness on test results.—MR. 9486

2.3.4, 6.4.2

The High-Vacuum Method of Determining Magnesium and/or Zinc in Aluminum Alloys. P. URECH AND R. SULZBERGER. *Aluminium*, **30**, 163-164 (1954) April; *Light Metals Bull.*, **16**, No. 11, 471 (1954) June 4.

A description of the high-vacuum (10^{-3} - 10^{-4} mm Hg) distillation apparatus and method developed by the Aluminium Industrie A.G. for the determination of magnesium and/or zinc in aluminum alloys.—ZDA. 9524

2.3.5

Inexpensive Method of Measuring Surface Finish. M. MATSUNAGA. *Univ. of Tokyo. Rev. Sci. Instruments*, **25**, 1221-1222 (1954) Dec.

A simple apparatus was designed to determine the quality of a surface finish by measuring the electrical contact resistance. Application of the device to corrosion testing is indicated.—NSA. 9568

2.3.5, 3.6.5

Criticism of Potentiometric Measuring as a Research Method for Corrosion. (In Hungarian). Mihály Solti. *Magyar Kémikusok Lapja (J. Hungarian Chemical Society)*, **9**, No. 10, 310-314 (1954) Oct. 25.

Evaluation of method on the basis of the literature and Hungarian investigations. Electrode potential of corroding metal; factors affecting the electrode potential. 20 references.—BTR. 9376

2.3.5, 3.6.8, 5.8.3, 3.8.4

A New Method of Investigating the Mechanism of Cathodic Processes and Its Application. M. SMYALOVSKII AND Z. SHKLYARSKAYA-SMYALOVSKAYA. *Bull. Acad. Sci. U.S.S.R. (Izvest. Akad. Nauk) Otdel. Khim. Nauk*, **1954**, 225-229; *Chem. Abs.*, **48**, No. 22, 13,476d (1954).

A soft-iron wire spiral coil, annealed at 900° in a hydrogen atmosphere, was suspended in electrolyte so that it was free to elongate. A platinum anode was used either as central wire or as an external gauze cylinder. On cathodic polarization, in the presence of traces of certain elements from groups V and VI the iron wire absorbed hydrogen and elongated. Organic inhibitor such as dibenzylsulfonic acid prevented penetration of hydrogen. Optimum concentration was easily determined by plotting elongation vs. concentration.—EL. 9528

2.3.6, 2.3.2

A New Method for Producing Corrosion Figures on Iron Surfaces. (In French.) JEAN BARDOLE AND JEAN MOREAU. *Compt. rend.*, **238**, 1416-1418 (1954) Mar. 29.

In a new method for the production of corrosion patterns on iron surfaces

1-2 cm sq electrolytically polished plates of Armco iron purified in hydrogen or of electrolytically prepared pure iron are immersed vertically as anodes, 3 cm. from the ferrous cathodes, in an aqueous solution of 2.5 g ammonium thiocyanate per liter. A current density of approximately 1.5 ma per sq cm is maintained for 4 min, sometimes followed by another exposure of 5-10 min after the samples have been washed with distilled water and alcohol. A single immersion is usually sufficient for pure iron and produces a limited number of large corrosion figures with sharp border lines. A second exposure usually results in smaller and more numerous corrosion figures of simpler form and with more distinct intercrystalline boundaries. The new method complements the Laue X-ray method for studying crystal orientation in that it reveals certain structural details more rapidly.—PDA. 9437

2.3.6, 2.3.7

Use of Zephirol Etching in the Investigation of Temper-Brittleness, Aging-Embrittlement and Stress-Corrosion in Steels. H. K. GÖRLICH, E. KOERFER, G. OBELODE AND H. SCHENCK. *Arch. Eisenhüttenw.*, **25**, 613-617; disc. 617-619 (1954) Nov.-Dec.

The suitability of Zephirol as etching reagent is illustrated by a series of experiments on low-alloy nickel-chromium steels (temper brittleness), carbon steels (aging embrittlement), and carbon steels and steels containing 0.22 percent carbon, 0.11 percent silicon, 0.58 percent manganese, 0.02 percent phosphorus, 0.032 percent sulfur, and 0.08 percent aluminum (stress corrosion). Data on fields of application and techniques of operation are given.—INCO. 9686

2.3.7, 7.7

The Behavior of Metallic Heating Elements in Service-Life Testing. (In German) A. SCHULZE AND D. BENDER. *Metall*, **9**, No. 1/2, 7-13 (1955) Jan.

Present status of short-time service-life testing of heating elements; equipment and methods; factors which affect test results. Photographs, table, and graphs. 17 references.—BTR. 9518

2.3.9, 2.4.3

Metals Engineering and Radioactive Materials. G. G. M. CARR-HARRIS. Canadian National Research Council, Technical Information Service Report No. 42, December, 1954, 37 pp.

Uses of radioisotopes in nondestructive testing, study of dynamic processes and in various instruments. 175 references.—MR. 9716

2.3.2

Transferring Flight Conditions to the Laboratory: Tests under Simulated Vibration, Varying Temperature and Humidity. H. V. CLARKE. *Engineering*, **178**, 822-825 (1954) Dec. 24.

Equipment developed for carrying out life tests on aircraft components and accessories in a more realistic manner than is normally possible at manufacturer's works. Results obtained will be published at a later date.—BNF. 9771

2.3.5, 7.7, 3.2.3

Insulating Films on Metal Contacts. D. G. FLOM AND R. H. SAVAGE. *Gen. Elec. Rev.*, **58**, No. 2, 59-61 (1955) Mar.

A simple method for measuring the resistance of small areas or spots on

metal surfaces is described. The basic tool, a platinum or gold exploring probe formed into a microscopic hairpin or loop, makes contact with the metal surface over an extremely small area (10^{-4} sq. cm. or less). Because metal surfaces are usually not homogeneous on a microscopic scale, this tool provides a means for determining the nature and magnitude of the local variations without damaging the surface film. To determine contact resistance, current is passed down one side of the loop and the voltage drop is measured through the other side with a potentiometer. The exploring wire can be used to detect invisible films as well as tarnish films. It is being used in vacuum to measure the influence of films from the atmosphere on the adhesion properties of metals and their contact resistance. The wire loop's extreme sensitivity disclosed some unusual effects. When an electrically isolated 60-cycle transformer was switched on and off near the sample, a sharp irreversible drop in contact resistance occurred. The resistance drop was the result of a voltage induced by electromagnetic radiation. This effect is believed to involve the electric breakdown of the surface film under a very high induced voltage gradient, with resultant production of a minute metal bridge at the site of breakdown.—ALL. 9367

2.3.6

Application of the Two-Beam Interference Microscope to the Study of Surfaces. W. I. GRUBE AND S. R. ROUZE. *J. Opt. Soc. Amer.*, **44**, No. 11, 851-860 (1954) Nov.

Interference microscopes that have recently become available have overcome many of the operational difficulties previously experienced. As a result, the two-beam interference microscope is finding increasing use in the laboratory in the study of surface topography. Present instruments are capable of examining surface detail in the range of 2 to 100 micro inches peak-to-valley. A number of applications to the study of surfaces important in industry are presented. These include: (1) the measurement of thickness of electro-deposited coatings, (2) the study of the levelling properties of electrodeposits, (3) measurement of the erosion or shrinkage of paint films upon weathering, (4) investigation of hardness measurement indentations, (5) examination of industrial sheet-steel finishes and (6) control of the geometry of accurate surface roughness standards. Replica techniques which make it possible to use the instrument to study curved and inaccessible surfaces are also discussed.—ALL. 9695

2.4 Instrumentation

2.4.3, 8.9.5

Non-Destructive Testing in Shipbuilding. R. J. KRIEGER, S. A. WENK AND R. C. MCMASTER. *Non-Destructive Testing*, **12**, No. 2, 27-33 (1954); *Welding J.*, **33**, 154s-160s (1954) March.

Radiography and magnetic-particle inspection are used quite extensively. The excavation and repair of defects is guided materially by frequent checking with the magnetic-particle method. Magnetic-particle inspection is also frequently used where both sides of a welded joint are inaccessible to radiography. In heavy joints, it is common practice to inspect for flaws with the magnetic-particle method after each two or three weld

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beads are put in. The ultrasonic method has been laboratory tested but has not found any service application to hull weld inspection as yet. A special ultrasonic device is now under development for the Bureau of Ships. This device contains two cathode-ray viewers, one to show a plane view and the other to show a cross-sectional view of the weld. The scanning device is mounted on a carriage designed to cling to a ship's hull magnetically and move along a weld joint at the rate of approximately 6 feet per min. Two jets are used to supply a layer of water used as the couplant for transmitted energy to the metal and pickling up the return signal.—TIME. 9169

2.6 Preparation and Cleaning of Specimens

2.6, 2.3.9

An Apparatus for Electropolishing Specimens for Metallographic Examination. E. C. SYKES AND OTHERS. *J. Inst. Metals*, 83, No. 5, 166-168 (1955) January.

Apparatus is described for electropolishing uranium or other metals. It is cheap to build and is said to be free from attack by even the most corrosive electrolyte likely to be used. Polished specimens are free from flow-lines produced by concentration of gas bubbles in the direction of flow of the electrolyte. It has been successfully used with uranium, stainless steel, copper and magnesium.—BNF. 9870

3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2, 1.6, 6.2.4, 3.7.3, 5.3.4

Survey of Low-Alloy Aircraft Steels Heat-Treated to High Strength Levels. Part I. Hydrogen Embrittlement. GEORGE SACHS AND WALTER BECK. Syracuse Univ. U. S. Wright Air Development Commission, Tech. Rept. 53-254 (Pt. 1), June, 1954, 95 pp.

Data on hydrogen embrittlement of high-strength steels are presented and analyzed. Many failures in aircraft reported for steel parts having a strength above 200,000 psi and in addition, many failures of steel bolts heat treated to a strength considerably below 200,000 psi were found to be associated with changes in the basic mechanical characteristics of the steel caused by cadmium plating or chromium plating. Heat treating or baking applied to relieve this hydrogen embrittlement were frequently only partly effective. Hydrogen in steel is highly mobile, and this explains the unusual mechanical features of hydrogen embrittlement and the conflicting results of the many tests which were applied to disclose and measure hydrogen embrittlement. The normal strength of a high-strength steel is found to be rarely affected while its ductility may be greatly reduced. Consequently, the strength of test specimens and parts which depends upon ductility may also be much reduced by hydrogen embrittlement. Furthermore, these effects are pronounced at low rates of straining or sustained loading but probably of no significance on impact loading. The magnitude of hydrogen embrittlement also depends greatly upon numerous mechanical, chemical, and electrochemical fac-

tors which are encountered in the making, shaping, heat treating, and finishing of aircraft parts. 43 references. (auth).—NSA. 9299

3.2.3, 6.3.20, 3.5.9

An Investigation of Scaling of Zirconium at Elevated Temperatures. Quarterly Status Report No. 6 (for) Sept. 2 to Dec. 2, 1954. W. M. BALDWIN, JR., D. J. GARIBOTTI, AND H. M. GREEN, Case Institute of Technology. U. S. Atomic Energy Comm. Pubn., AECU-2976, Dec. 7, 1954, 8 pp.

The scaling behavior of zirconium in nitrogen was investigated in the temperature range 800 to 1200° C. The increase in thickness with time at temperature of the scale and of the solid solution layer near the scale was determined for zirconium specimens scaled in air. The hardness gradient of the metal after scaling in air was studied. (auth).—NSA. 9351

3.2.3, 6.3.20, 3.5.9

An Investigation of Scaling of Zirconium at Elevated Temperatures. Quarterly Status Report No. 5 (for) June 2 to Sept. 2, 1954. W. M. BALDWIN, JR., D. J. GARIBOTTI, AND H. M. GREEN, Case Institute of Technology. U. S. Atomic Energy Comm. Pubn., AECU-2928, Sept. 17, 1954, 11 pp.

Several aspects of the oxidation of zirconium in air were investigated. Specimens were scaled in atmospheres of oxygen and nitrogen at 800°, 900°, and 1000° C to determine the effect of nitrogen on the scaling characteristics of zirconium. Data are presented graphically. (auth).—NSA. 9339

3.2.3, 6.2.2

Decomposition of the Wustite Phase. (In German). L. CASTELLIZ, W. DE SUTTER AND F. HALLA. *Monatsh. Chem.*, 85, No. 3, 487-490 (1954) June.

Experiments show significant amounts of Fe₂O₃ are formed at 190° C on sheet iron heated in air. Two references.—BTR. 9278

3.3 Biological Effects

3.3.4, 7.5.4

Iron Bacteria in Gasholder Water. A. R. MITCHELL. *Gas. J.*, 281, 845-847 (1955) Mar.

Describes growth and control. Photographs.—BTR. 9618

3.4 Chemical Effects

3.4.6, 2.1.1

Corrosion. MARS G. FONTANA. *Ind. and Eng. Chem.*, 46, No. 9, 85A-86A, 88A (1954) Sept.

The effects of aeration or dissolved oxygen in a liquid environment on the corrosion rates of metals and alloys are discussed. Suggested methods of aeration and deaeration by the addition of nitrogen or argon and their effects on corrosion are presented. The corrosion rate of Monel in sulfuric acid indicated an increase when saturated with nitrogen (air free). A decrease of corrosion is shown when the boiling point is reached due to the lack of solubility of oxygen at this temperature. The use and advantages of mils/yr. as a standard expression for corrosion rate are given. The effect of oxidizing capacity of solution on corrosion rates of stainless steel, aluminum, Hastelloy C, Monel, iron, and copper is given.—NSA. 9509

3.4.6, 3.2.2, 6.2.5

Influence of Liberated Gases on the Pitting of Stainless Steels. (In Italian.) C. BIGHI. *Metallurgia italiana*, 46, special supplement to No. 5, 42-43 (1954) May. Theoretical study. Table, diagram, 9 references.—BTR. 9502

3.4.6, 3.6.8

Aspects of the Influence of Oxygen in Wet Corrosion Phenomena. (In Italian.) G. BIANCHI. *Metallurgia italiana*, 46, special supplement to No. 5, 30-31; disc., 32 (1954) May.

Overvoltage of cathodic reduction and diffusion of oxygen. Charts.—BTR. 9504

3.5 Physical and Mechanical Effects

3.5.1, 1.6, 3.8.4

Physical Properties of Solid Materials. C. ZWIKKER. Book, 1954, 300 pp. Pergamon Press, London.

The author has attempted to produce a summary of the physics of solids in one volume. His chapters include constitution, heterogeneity, anisotropy, elasticity, plasticity, thermal properties, transformations, ferromagnetism and ferroelectricity, electronic properties, the surface, etc.—BNF. 9470

3.5.3, 3.5.8

Hardness of Solids. D. TABOR. *Endeavour*, 13, No. 49, 27-32 (1954) Jan.

Relation of indentation hardness to plastic yield-stress, leading to a physical explanation of Mohs scratch-hardness.—BNF. 9538

3.5.8, 8.9.4

How Do the Mysterious Grooves on Railroad Rails Arise? (In German). MAX FINK. *Umschau Wiss. u. Tech.*, 54, No. 16, 499-502 (1954) Aug. 15.

Laboratory investigations on an Amster test machine showed that the mysterious noise-producing grooves arising on railroad rails and covering 47 percent of the total rail system of German railroads are traceable to the initial formation of iron oxide layers on the rail surface, and to the subsequent rhythmic pulverization of these layers by frictional vibration plus sliding in service. This process leads to the formation of small grooves of a characteristic sinusoidal structure, with a distance of 4-5.5 cm between crests and a difference in height between crest and trough of 0.1-0.3 mm, occasionally up to 0.4 mm. Chemical analysis of the oxide layer showed it to correspond to the formula ferrous oxide. X-ray analysis, however, showed the presence only of iron, Fe₂O₃, and ferric oxide, the outer layers having the higher oxygen content. Both sliding action, which chemically activates the iron surface, and oxygen are necessary for groove formation to occur. Absorption of nitrogen at the sliding points of the groove crests may or may not be another factor. Other investigations on hardenable steels suggest that spontaneous temperature elevations occurring at the sliding points of the groove crests may result in the formation of hardened martensite. Groove formation has been observed, however, on pure iron, copper, and aluminum.—PDA. 9441

3.5.8, 6.3.6, 3.7.3

Internal Stresses and Warping in the Manufacture of (Brass) Watch-Movement Blanks. (In French and German).



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W. BRANDT. *Pro-Metal*, 6, No. 39, 354-359 (1954).

The components of watch-movement blanks are machined from cold-rolled brass. The internal stresses introduced by rolling can lead to stress-corrosion (season-cracking) and warping; the latter presents a serious problem in view of the precision of the mechanism. Experiments were carried out on specimens cut from brass strip (copper 60, zinc 38, lead 2 percent) parallel to and perpendicular to the direction of rolling. A groove was milled across the strip and the deflection at a point 100 mm. away was measured with a dial gauge; the deflection was plotted against the depth of the groove. Warping was found to be more severe in the direction of rolling than perpendicular to it. Stress-relieving for 1 and 3 hr. at 225°, 260°, and 300°C resulted in the expected decrease in warping, but did not overcome this difficulty entirely. Treatment at higher temperatures lowers the hardness of the strip. Even stress-relieving at temperatures low enough to leave the hardness and U.T.S. substantially unaffected tends to raise the ductility slightly, and this has a detrimental effect on the machinability.—MA. 9311

3.5.8, 6.2.3, 3.7.3

Fatigue Strength of Flame-Cut Specimens in Bright Mild Steel. F. KOENIGSBERGER and Z. GARCIA-MARTIN. *Brit. Welding J.*, 2, No. 1, 37-41 (1955) Jan.

Investigation of fatigue strength of pieces flame-cut from bright mild steel strip, with particular reference to influence of quality of cut. Main factors influencing fatigue strength are condition of upper (melted) edge and lower edge and the quality of flame-cut face (depth, shape of drag lines). Comparative tests with specimens of same material machined to a commercial and a high-quality finish showed that flame-cut specimens have an endurance limit 7% lower than the former and 30% lower than the latter. Illustrations, graphs, 3 references.—INCO.

3.5.9, 6.2.4, 6.2.5

Elevated Temperature Properties of Steels Containing: (1) 0.6% Chromium, 0.6% Molybdenum; (2) 2.25% Chromium, 1% Molybdenum; (3) 22% Chromium, 18% Nickel. G. DELBART AND A. CONSTANT. *Rev. Met.*, 51, 845-868 (1954) Dec.

Summary of results obtained by Commission de Etude des Metaux a Chaude, of IRSID, since 1947, in tests carried out in order to define characteristics at elevated temperatures of French steels used in power stations. Steels were tested at normal temperatures of use up to 20,000 hours. Results were extrapolated up to 100,000 hours: stress-rupture and creep data from each assessed at rate of stress in plant working at high temperatures. Summary of results of tests on the same steels carried out by French makers is given.—INCO. 9769

3.6 Electrochemical Effects

3.6.8, 6.3.15

Hydrogen Overvoltage (Cathodic Potential) on Titanium in Acidic and Basic Solutions. M. E. STRAUMANIS, S. T. SHIH AND A. W. SCHLECHTEN. *J. Phys. Chem.*, 59, No. 4, 317-321 (1955) April.

Cathodic potential, or hydrogen overpotential, measurements on titanium electrodes at various current densities in the presence of air were made by the direct method in hydrofluoric, hydrochloric, hy-

drobromic, sulfuric, acetic and trifluoroacetic acids, sodium hydroxide and potassium hydroxide, using different concentrations of these electrolytes at room temperature, 24-32 degrees. Overpotential values become more negative with increasing current density. Graphs and 32 references.—INCO. 9858

3.7 Metallurgical Effects

3.7.2, 6.3.4

Uranium in Heat-Resisting Alloys. G. T. HARRIS AND H. C. CHILD. *J. Iron Steel Inst.*, 179, Pt. 4, 347-349 (1955) April.

Uranium would be expected from its position in periodic table to be a useful strengthening element in heat-resisting alloys. Limited amount of work was carried out to show that this is so for cobalt-base alloys. Effectiveness of uranium is comparable to that of niobium but twice the weight percentage of the former is required for same effect. Uranium has a more deleterious effect on forgeability than niobium and high-uranium alloys were not forged successfully. Optimum uranium-bearing alloy has very similar creep, rupture and scaling properties to its niobium-bearing equivalent. Compositions of 12 nickel, 45% cobalt alloys are tabulated and include Alloy Nos. L.714, 715, 716, 717, L.866, 867, 868, 869, 870, 871, 872 and G.32. Table and graphs.—INCO. 10310

3.7.3, 7.10. 6.2.2

Cast Bolts for Pipe Joints. C. K. DONOHUE. *Am. Cast Iron Pipe Co. Metal Progress*, 67, No. 5, 86-88 (1955) May.

Cast bolts are mass-produced by Am. Cast Iron Pipe Co. in metal molds and malleablized by annealing. Because of quick freezing in metal molds, silicon content of iron can be run as high as 3%. Up to 1% copper is added for corrosion resistance. Bolts combine good mechanical properties and corrosion resistance for mechanical joints in cast iron pipe lines. Typical microstructure of annealed bolt metal, essentially temper carbon nodules in matrix of silico-ferrite, is shown. Nuts are gray iron, shell molded.—INCO. 10025

3.7.3, 6.4.2

Fusion Welding of Aluminium Alloys. Part VII. Recording Porosity in Aluminium-Alloy Welds. P. T. HOULDCROFT AND A. A. SMITH. *Brit. Welding J.*, 2, No. 2, 67-74 (1955) February.

A method of classifying and reporting the severity of porosity in welds, as observed in microsections, has been developed. Severity of porosity is defined by two numbers and a letter. Porosity can be estimated in zones of a weld where density specimens could not be prepared. Code may be applicable to non-ferrous materials other than aluminum alloys.—BNF. 10028

3.7.3

Plastic Bonds Carbide to Steel. W. E. FAWCETT. *Am. Machinist*, 99, No. 5, 97-99 (1955) February 28.

With a plastic epoxy adhesive, carbide can be successfully bonded to steel at 300 degrees F. Advantages of method include less distortion, shear strength of 8000 psi for epoxy adhesives and size of bond possible. Only processing required is preheating metal and carbide parts to 250-300 degrees F and curing clamped assembly for period of time depending

on oven temperature maintained. Curing times and temperatures for epoxy adhesives are tabulated. Fit between parts should be 0.003-0.006 for maximum strength. Applications include wear parts such as shear knives, work rests for grinders and wear guides for abrasive materials. Illustrations.—INCO. 10277

3.7.3

Weldability of Wrought High-Alloy Materials. R. P. CULBERTSON. Haynes Steel Co. *Welding J.* (N. Y.), 34, 220-230 (1955) March.

Development work has been centered on the joining and forming of alloys capable of resisting corrosion, high-temperatures plus oxidation, stresses, and mechanical shocks. The procedures for joining and the properties to be expected of weld joints in these alloys, are discussed. Tests were made with nickel-molybdenum alloys, nickel-molybdenum-chromium alloys, cobalt-chromium-tungsten-nickel alloys, and N-155, an iron-base alloy with large percentages of chromium, nickel and cobalt. These were welded by the submerged arc, inert-gas-shielded arc and metallic-arc methods. The properties of the weld joints and the weld metal were satisfactory and fell within acceptable limits for alloys of this type. All of the alloys listed will produce weld joints meeting the minimum tensile requirements for the parent metal. The alloys tested have characteristics of the austenitic type and, generally speaking, can be welded by all of the methods common to the austenitic stainless steels. Certain of the alloys, however, exhibit characteristics that are peculiar to that alloy composition during welding and fabricating operations. Nickel-molybdenum alloys, for example, are subject to stress-cracking in the hot-short range and are the most critical of the alloys in this respect. Nickel-molybdenum-chromium and cobalt-chromium-tungsten-nickel alloys are subject to work-hardening during forming operations. These alloys, however, are not as susceptible to stress cracking during welding of restrained components as are the nickel-molybdenum alloys. N-155 alloy is subject to micro-fissuring if proper welding techniques are not used. All of these alloys can be welded satisfactorily when proper procedures are followed. (auth)—NSA. 9975

3.7.3

Innovations in Jet-Engine Manufacture. E. W. BARTLE. *Machinery*, 61, No. 10, 210-218 (1955) June.

Describes outstanding new tools and methods used in quality production of a new turbo-jet aircraft engine at Orenda Engines Ltd., Ontario. Mist cooling is used during milling of inner cone of turbine nozzle-box which is made from a stainless alloy. Automatic, tracer-controlled milling machine is used to cut large irregular holes in welded stainless-steel outer casings for turbine nozzle-box. Microbraz powder, a heat-and-corrosion-resistant, nickel-chromium-base alloy, is used for brazing stainless steel stator segment sub-assemblies. Illustrations.—INCO. 9920

3.7.3

Short Cycle Anneal Restores Ductility in Cold Extrusions. C. A. TURNER, JR. *Iron Age*, 175, 96-99 (1955) March 10.

Description of equipment and operating procedures for fast and selective annealing of steel rocket heads. Photographs, micrographs, diagram.—BTR. 9884

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3.7.2, 6.2.1

Graphitization of Certain Iron-Carbon-Titanium Alloys. A. B. BEACH AND R. W. HEINE. Paper before Am. Foundrymen's Soc., 58th Ann. Mtg., Cleveland, May 8-14, 1954. *Trans. Am. Foundrymen's Soc.*, 62, 231-234; disc., 235 (1954).

Work with the iron-carbon-titanium alloys showed that titanium promoted equilibrium structures wherein graphite, ferrite, and titanium carbide were the phases present after heat treatment. Diagram of Tofaute and Buttinghaus is concluded to represent meta-stable conditions in which the iron carbon phase is quite unstable, in the high carbon range studied. Alloying behavior of titanium, in being entirely a former of titanium carbide, shows that it is not necessary for an element to dissolve in ferrite in order to promote graphitization of iron carbide in ternary iron-carbon alloys. Since titanium is tied up as a carbide in the graphitizable alloys, no hardening or strengthening effects on the ferrite can be expected. Photomicrographs, tables, and 9 references.—INCO. 9791

3.7.3

Rosin-Cored Solder Wire: "Activated" and "Non-Activated" (Non-Corrosive.) British Standard 441:1954, 14 pp. British Standards Institution, 2 Park St., London, W. 1.

Specification for rosin-cored solder wire of circular cross-section, having one or more continuous cores of flux "activated" or "non-activated" (wood or gum rosin with or without an activating agent; halogen and acid contents are specified). —BNF. 9790

3.7.3, 3.6.6

Adhesives Join the Assembly Line. THOMAS F. HRUBY. *Steel*, 135, No. 4, 88-91 (1954).

In a general account of the application of adhesives, examples are cited of their use in metal joints. Improved fatigue characteristics over riveted structures are claimed, as well as better corrosion-resistance when joining dissimilar metals. —MA. 9720

3.7.3

Contemporary Metal Processing Techniques in Russia. N. H. POLAKOWSKI. *Metal Progress*, 67, No. 1, 98-103 (1955) Jan.

Notes on somewhat meagre information available in Russian journals and books export of which is permitted, including powder metallurgy; automation in metal working; continuous casting; automatic arc welding of aluminum alloys; mechanical working; and various aspects of ferrous metallurgy.—BNF. 9606

3.7.3, 5.12

Improvement of Case Hardened Parts by Controlling Internal Stresses. J. POMEY. *Metal Progress*, 67, No. 1, 147-153 (1955) Jan.

Three heat treatment schedules for carbo-nitriding automobile parts to insure high and controlled compressive stresses in the case are discussed. They give an ensemble of properties in low-alloy or plain carbon steels intermediate between those presented by parts of higher chromium and nickel carburized at 1650° F. in the conventional ways and rapidly quenched, and parts made of chromium or aluminum steels nitrated a long time at low temperatures. Hertzman hardness test was used for determination of stresses at surface of the steels.

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Good results were achieved with nitrogen atmospheres without having to resort to expensive alloying elements in the steels. Heat treating so as to put optimum compressive stresses in correct position has increased the life of automobile parts and prevented fatigue failures or wastage from wear. Graphs and photomicrographs.—INCO. 9603

3.7.3, 6.2.4

Tentative Specifications for Low Alloy Steel Arc-Welding Electrodes. Brochure, June, 1955, 16 pp. American Welding Society, 33 West 39th St., New York 18, N. Y., and American Society for Testing Materials.

Electrodes are classed by chemical analysis in addition to the usual classification by mechanical properties. This will permit user to choose alloys that

will provide weld metal of properties and mechanical characteristics which will match basis metal closely in corrosion resistance and otherwise. An appendix provides a useful guide to the understanding and best use of the specification. 9544

3.7.3, 6.4.2

Problems of Forging (High-Strength Aluminum Alloys). G. W. RICHARDS. *J. Inst. Production Engrs.*, 34, No. 3, 152-157; disc., 180-188 (1955) Mar.; *Metal Ind.*, 86, No. 4, 63-66 (1955) Jan. 28; *Metal Treatment*, 22, No. 113, 72-76 (1955) Feb.

Importance of good quality surface, and methods of examining surfaces; internal stress arising from quenching; control of quench temperature; effect of anodizing on quenching behavior.—BNF. 9660

3.7.3, 5.12

Sub-Zero Chilling as a Metallurgical Process. R. S. JAMISON. *Machinery*, 85, 603-606 (1954) Sept. 17.

Refrigeration used to stabilize alloy steels, for various purposes, and relieve stresses in aluminum and magnesium castings; also shrink fitting.—BNF. 9372

3.7.3, 5.3.2

Spot Welding of Tinplate. M. J. RICHARD and D. W. PETCHEY. *Brit. Welding J.*, 1, No. 10, 433-440 (1954) Oct.

Purpose of investigation is to establish conditions under which largest number of sound welds can be made without adjusting the welding machine. In addition, tests show copper-chromium to be best electrode material, with chromium plating as most useful coating for tip.—BNF. 9320

3.7.3, 3.5.9

Fasteners for High Temperature Service. (Above 650°C) J. L. EVERHART. *Materials & Methods*, 40, No. 3, 104-106 (1954) Sept.

A brief general discussion of problems presented by requirements for fasteners for high temperature use, with notes on the design of a few suitable locknuts and bolts, and a table of properties of some high temperature alloys. 6 references.—BNF. 9629

3.7.3, 3.5.8, 6.4.2

Effects of Finishing on (Fatigue of) 75S-T6 Aluminium Alloy. M. J. BROWN. *Product Eng.*, 25, No. 9, 163 (1954) Sept.

Gives fatigue curves for machined, grit blasted, and polished specimens. The curves cross, showing that finish should be selected according to the predicted service conditions. 75S-T6 is aluminum—6 percent zinc—3 percent magnesium—2 percent copper—0.3 percent chromium—0.2 percent manganese.—BNF. 9281

3.7.3

Joining at Low Temperatures: Fundamentals and Applications. G. M. BLANC. *Giesserei*, 41, 700-703 (1954) Dec. 23.

Fundamentals of low-temperature welding and importance of fluxes and electrodes. Applications mentioned include use of high-nickel electrode for cold-welding of grey cast iron and of 25/20 chromium-nickel steel sheet at high rates. Mention is made of refacing of worn parts, example being given of facing with a chromium-nickel-molybdenum electrode as applied to a turbine wheel. Advantages of low-temperature welding are given.—INCO. 9337

3.7.3

1) Soldering: Some Consideration of the Process and Its Mechanism. 2) Testing of Solder Fluxes. P. M. FISK. *Sheet Metallic Inds.*, 31, No. 327, 567-569 (1954) July; *ibid.*, 31, No. 329, 743-745, 747 (1954) Sept.

1) An analysis of the soldering process, particularly of copper alloys; effect of oxide layer, action of flux, wetting by solder.

2) Critical account of methods used in practice for testing fluxes for wetting power, effect on joint strength, speed of operation, corrosivity. Possibility of adapting flux composition to solder composition, and toxicity of fluxes, are also discussed.—BNF. 9430

3.7.4, 3.5.8, 3.7.3, 3.8.4

Theory Relative to the Influence of Hexagonal Elements and Compounds in

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Polycrystalline Groups. (In French.) A. PAUDRAT. *Metallurgie, Corrosion-Industries*, 29, No. 350, 372-379 (1954) Oct.

Sulfonation and sulfocementation; production of free-cutting steels; decrease of properties of sulfur steel during cooling and heating; fretting corrosion. Diagrams. 34 references.—MR. 9457

3.7.4, 3.8.4, 6.4.2

Adsorption of Impurities on the Block Boundaries in Aluminium. (In Russian.) I. E. BOLOTOV AND YU. D. KOZMANOV. *Doklady Akad. Nauk S.S.S.R.*, 95, No. 2, 293-295 (1954) Mar. 11.

Single crystals of 99.7 percent and 99.99 percent aluminum were bent and annealed to produce polygonization, then electro-polished. Microscopic examination revealed a mosaic structure only in the case of the commercial-purity metal, although X-ray examination showed that polygonization had occurred in the 99.99 percent aluminum. Various other experiments are reported. It is suggested that the mosaic structure is made apparent in etching because of the impurities segregated at the boundaries of the blocks.—BNF. 9499

3.7.3, 6.4.2

Hard Soldering: New AID Approved Process for Aluminium and Aluminium-Alloy Sheet. W. J. SMELLIE. *Aircraft Prod.*, 17, No. 5, 181-185 (1955) May; *Metal Ind.*, 86, No. 16, 307-310 (1955) April 22; *Sheet Metal Ind.*, 32, No. 337, 365-366 (1955) May.

Two zinc alloys (Thessal A and Thessal P.12) suitable for use as solders for aluminum have been developed and give joints with good corrosion resistance. Properties of the solders (but not composition) details of the soldering process, joint properties and design, applications. These are the only aluminum solders to have AID approval and form the subject of a patent application. They are not suitable for magnesium or magnesium-rich alloys. Another account, by R. C. Jewell, in *Welding and Met. Fabrication*, 23, No. 5, 179-182 (1955) May.—BNF. 9842

3.7.3, 6.3.6, 7.2

Strength of Bent Copper Tube. G. S. SANDHAHL, JR., AND W. M. BALDWIN, JR. Paper before Am. Soc. Testing Materials, 58th Ann. Mtg., Atlantic City, June 26-July 1, 1955. ASTM Preprint No. 81, 1955, 20 pp.

Investigation was undertaken to determine whether copper tubes are weakened by bending. Results provide evidence that, in spite of this thinning of the wall, the bursting strength of the copper tube is not impaired by bending. Annealed copper tubes with diameters from $\frac{5}{8}$ -1 $\frac{1}{2}$ inch and in two wall thicknesses were tested. Analysis of the strains involved in bending was also made. Equation was derived which fits the conditions of draw bending and gives the bending strains in terms of the bend radius. Tables, graphs and fourteen references.—INCO. 9823

3.7.3, 5.12

Steam Heat Treating Boosts Processing Efficiency. F. L. SPANGLER. *Steel*, 136, No. 19, 82-84 (1955) May 9.

Steam-heat-treating is used for scale-free tempering, annealing and stress relief, to lengthen service life of tools and cast-iron parts, for bluing and to improve compressive strength and hardness of powdered iron parts. Method imparts wear and corrosion resistance and serves as a surface preparation for painting, ja-

panning and lacquering. Corrosion resistance of powdered iron parts is increased if parts are oil dipped after steam treatment. Specific applications are discussed and tabulated and steam-heat-treating cycles for ferrous and non-ferrous metals are briefly outlined.—INCO. 9811

3.8 Miscellaneous Principles

3.8.2, 6.3.8, 3.4.2

The Mechanism of the Decomposition of Hydrogen-Peroxide on Metallic Lead. (In German.) TIHOMIL MARKOVIC. *Werkstoffe und Korrosion*, 6, No. 3, 136-141 (1955) Mar.

The results obtained from the potentials of the galvanic cells lead-platinum and lead-silver, plotted against time, de-

termined the mechanism of catalytic decomposition. Graphs, tables. 9 references.—BTR. 9594

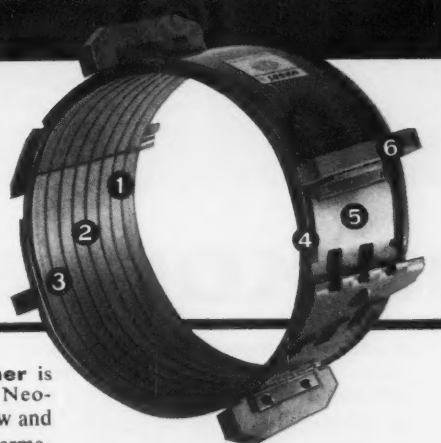
3.8.2, 3.6.8

An Electrochemical and Structural Investigation of the Processes Occurring at Silver Anodes in Sulphuric Acid. P. JONES AND H. R. THIRSK. *Trans. Faraday Soc.*, 50, No. 7, 732-739 (1954) July.

The behavior of silver on anodic polarization in 2N-sulfuric acid closely resembles that of lead. The silver-sulfuric acid system has been studied by following potential variations during constant-current polarization; the deposits formed on the electrodes were examined by optical microscopy, and by electron and X-ray diffraction. Anodic oxidation follows the path: $\text{Ag} \rightarrow \text{Ag}_2\text{SO}_4 \rightarrow \text{AgO} + \text{O}_2$. The oxidized electrode is reduced by the

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* Patents Pending



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put that knowledge and experience at your disposal in cutting your corrosion costs, we are initiating a series of informal reports. The first appears at the right.

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COATINGS AND ENAMELS

how to CUT CORROSION LOSSES

a report by Koppers Company, Inc.



W. E. Kemp,
Manager of the Technical Dept.

Although corrosion losses are never listed on a profit and loss statement, they represent a considerable—and often unnecessary—loss to every industry. Preventing this loss is a big part of our business as the world's leading producer of coal tar base enamels and coatings.

* * *

Many times every week we get a phone call, wire or letter asking the same, often harried, question: "Can you help me with this corrosion problem . . . ?" In most cases, we *can* help, and are most happy to do so. In fact, our Coal Tar Technical Department is designed to facilitate such help.

Basically, we have two groups within the Technical Department—the Development Group and the Technical Service Group. They are both headquartered at Verona, Pa., in a new building with the latest facilities for laboratory work and pilot plant operations. This building also houses the Quality Control staff of the Tar Products Division. These ten chemists cross-check the quality control operations of each plant.

Our Development Group consists of a General Supervisor, Mr. Frank Charlton, and two project leaders who supervise the activities of nine chemists and engineers. They work constantly to up-grade the effectiveness of Bitumastic coatings and to develop new coal tar coatings.

Our Technical Service Group, supervised by Mr. C. U. Pittman, also includes two project leaders and four laboratory workers. These men work in close liaison with our customers, distributors and sales engineers to help them specify the best coating and the most economical application for the job.

We also retain the services of two widely-known coating and corrosion scientists: Dr. W. F. Fair, Jr. and Mr. R. C. Stromquist. Both of these men—and each member of the Technical Department supervisory staff—have had more than 20 years' experience in the bituminous coating field. Dr. Fair and Mr. Stromquist work with all departments and, through first-hand field experience in their extensive travel, alert us to customer needs for new or modified protective coatings.

* * *

Naturally, many of our technical personnel participate quite actively in industrial and technical organizations. One of our coatings consultants, Dr. W. F. Fair, Jr., actually is serving full time this year as president of the National Association of Corrosion Engineers. Altogether, 70% of our men are members of scientific and technical societies. They participate actively on committees working on industry-wide problems.

In future columns, we plan to report to you on specific corrosion problems in such industries as steel, gas, petroleum, water supply and sewage and industrial wastes. In the meantime, we'd like to hear about your problems. Write to Koppers Company, Inc., 1301 Koppers Building, Dept. 100F, Pittsburgh, Pa.



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path: $\text{AgO} \rightarrow \text{Ag}_2\text{SO}_4 \rightarrow \text{Ag} + \text{H}_2$. Fourteen references.—MA. 9721

3.8.2, 6.3.10, 3.2.3

An Investigation into the Electron-Exchange Mechanism between Absorbed Foreign Molecules and the Surface of Thin Nickel Layers at Low Temperatures by Means of Electrical-Resistance Measurements. R. SUHRMANN AND K. SCHULZ. *Z. physikal. Chem. (Frankfurt)*, 1, No. 1/2, 69-97 (1954).

Thin films of nickel were evaporated on to glass, and their resistance changes measured at 90° and 293° K. after the surface absorption of argon, oxygen, hydrogen, carbon monoxide, nitrogen monoxide, water, C_2H_6 , and C_6H_6 . The quantity of gas absorbed was also measured for argon, oxygen, hydrogen, and carbon monoxide. The following results were found, where θ is the maximum number of irreversibly absorbed gas molecules/surface nickel atom and ΔR the maximum resistance change expressed as thousandths of the initial value:

	Temp., °K.	θ	ΔR
A	90.3	0.06	0
	293.3	...	0
O	90.5	1.13	+55.7
	294.9	3.43	+99.3
H	90.6	0.34	-9.9
	293.4	1.53	-34.5
CO	90.4	0.89	+8.3
	294.1	0.60	+36.4

At room temperature the absorption of hydrogen and carbon monoxide, but not that of oxygen, is partly reversible. Pretreatment of the nickel surface with oxygen at 90.5° and 293.5° K. blocks the absorption of hydrogen and suppresses the resistance effect. Carbon monoxide pretreatment at 294.5° K. is similar. Pretreatment with carbon monoxide at 90.4° K. prevents absorption of oxygen. Again pretreatment with hydrogen at 90.5° K. prevents carbon monoxide absorption, while Pretreatment with argon only influences subsequent carbon monoxide absorption and resistance effect in so far as argon is absorbed. Absorption of nitrogen monoxide at 90° K. causes a resistance increase, but water causes a reduction. The absorption of π -electron-containing compounds such as C_2H_6 , $\text{CH}(\text{C}_6\text{H}_5)_3$, and C_6H_6 , causes a resistance reduction. The resistance changes are explained in terms of the electron exchange between the electron shells of the absorbed molecules and the electron gas of the nickel layer. The nature of the exchange is related to the electron structure of the molecules. 20 references.—MA. 9751

3.8.3, 3.8.2, 3.4.7

Relation of the Corrosion Rate of Iron to the pH of Solution, and the Passivation of the Metal in Alkaline Solutions. (In Russian.) L. K. LEPIN, A. IA. VAIWADE AND Z. F. OSHIS. *J. Phys. Chem., USSR* (Zhur. Fiz. Khim.), 29, No. 2, 350-355 (1955) February.

Oxidation kinetics of iron in various media; transition from γ to α form. Retardation of corrosion at certain pH values. Graphs, table, diffraction patterns. 10 references.—BTR. 10086

3.8.4, 6.3.6, 3.2.3

Rate of Formation of Film on Metals and Alloys. G. P. CHATTERJEE. *J. Applied Phys.*, 26, 363-365 (1955) April.

The rate of atmospheric corrosion of copper-zinc and copper-magnesium alloys is retarded by aluminum or manganese and the law of the growth of film

in the case of copper-zinc alloys changes over from the parabolic to the logarithmic law on the addition of aluminum or manganese. For copper-magnesium alloys under a given set of conditions the law of the growth of film is governed by $x^2 = k_1 \log t + k_2$, where x is the film thickness, t is time and k_1 and k_2 are constants. It has been indicated that some experimental data on the corrosion of metals and alloys may be quantitatively represented if two or more functions, representing different mechanisms of the growth of film, are taken into consideration simultaneously. (auth)—NSA. 9933

5. PREVENTIVE MEASURES

5.1 General

5.1.1

Principles of Corrosion. Parts III, IV. W. H. J. VERNON. *Corrosion Prevention and Control*, 2, 19-28, 44; 21-29 (1955) Jan., Feb.

Part III. General review of methods based on modifications of design, materials, or environment. Diagrams, table, graphs.

Part IV. Resistance improved by purifying and alloying. Coatings of reaction product, organics, inorganics, and metals for control. Table, graphs, diagram. 10 references.—BTR. 9856

5.2 Cathodic Protection

5.2.1

The Development of Cathodic Protection Against Corrosion of Metallic Constructions Under Water and in Soils. J. ILIOVICI. In German: *Werkstoffe u. Korrosion*, 6, No. 4, 181-189; disc, 197-198 (1955) April; In French: *Corrosion et Anti-Corrosion*, 3, No. 2, 66-77 (1955) March-April.

First constructions cathodically protected in France were buried steel pipelines. Today all water pipes are thus protected and protection of gas pipes in the valley of the river Po is being investigated. Cathodic protection is being used for telephone and power cables, metallic pile foundations, walls of quays and wharves, sluices in harbors, ships and floating docks. Different methods to establish the cathodic potential of protection are discussed. Various types of anodes and the economics of cathodic protection are considered.—INCO. 10045

5.2.1

Test Methods to Determine the Resistance of an Insulating Joint. E. T. PEARSON. *Corrosion*, 11, No. 12, 535t-541t (1955) December.

Test methods for determining the resistance of an insulating joint under a number of conditions are discussed. Consideration is given to the purposes for which insulating joints are commonly used. A detailed study is made of the problem of determining the true resistance of an insulating joint installed between two buried structures when a direct, accurate current measurement is not possible on either structure at the insulating point. The Parallel computation, Delta computation and the null circuit methods are discussed in connection with this problem. 10320

5.2.1

Cathodic Protection of Underground Structures. Parts I, II. W. G. WAITE. *Cor-*

rosion Technology, 2, Nos. 2, 3, 46-49, 83-86 (1955) Feb., Mar.

Part I outlines methods of cathodic protection; galvanic, impressed current and current drainage methods; potential measurements. Part II. Development and choice of materials for the best protection: galvanic anodes, anodes for use with impressed current and graphite anodes. Suitable applications and limitations of cathodic protection.—BNF. 9861

5.2.1

For Cathodic Protection Power Rectifiers or Sacrificial Anodes? R. M. WAINWRIGHT. *Gas*, 31, No. 3, 77-79, 81-82, 84 (1955) March.

Aside from situations where only sacrificial anodes or only rectifiers are feasible, there are situations where both may be used to advantage. In such circumstances, the engineer must turn to economic analysis and install the type of cathodic protection power which will give the cheapest immediate solution to the problem. Examination of the methods of deciding how to select the proper source of power based on these economic factors are considered. Several typical cases of cathodic protection applied to underground systems are covered. 7 references.—INCO. 9864

5.2.1, 4.5.1

The Factor of Soil Resistivity in Establishing Corrosion Control. B. J. WHITLEY, JR. *Gas*, 31, No. 3, 137, 140 (1955) March.

Soluble salts, temperature, pressure and moisture content cause soil resistivity to change constantly. Soil resistance is an indication of corrosion rate and location, depending on relative magnitude, not absolute resistivity. Choice of sites and design of ground beds depend on the availability of low resistance soil, which definitely affects the operation and power of the beds.—INCO. 9847

5.2.1

How to Design Cathodic Protection Systems. WAYNE A. JOHNSON. *Pipe Line Ind.*, 2, 58-60, 64 (1955) March.

Soil and current requirements; equipment tests and selection. Photographs, diagrams, graph.—BTR. 9960

5.2.3

"Hot Fence" Is Unexpected Ground Bed Hazard: Topic of the Month. F. E. STETLER. *Corrosion*, 11, No. 5, 17 (1955) May.

While setting up steel pipe posts for a school fence it was discovered that the school yard was adjacent to a ground bed for a rectifier providing cathodic protection for nearby lead-sheathed underground toll cables. Inspection showed that workmen had inadvertently located three posts with dangerous geometry of tangency between the wet concrete and buried electrodes. Thus pipes set in wet concrete became in effect aerial extensions of buried electrodes. To eliminate the hazard the rectifier was deenergized until the ground bed was relocated.—INCO. 10208

5.2.3

Graphical Method of Checking Stability of Cathodic-Protection Rectifier Stacks. C. D. STROUD. *Oil Gas J.*, 53, No. 47, 126, 128, 130 (1955) March 28.

Growing number of miles of pipeline with cathodic protection increases importance of proper operation and maintenance of rectifier equipment. Degree of

stability of rectifier can be determined from graphical evaluation of open-circuit and short-circuit characteristics of rectifier cell. Variable ac voltage source, dc ammeter and shunt sized to measure rated output current of rectifier, ac voltmeter for input voltage, and ac milliammeter (0-1,000) for measuring reverse current are required. Short-circuit and open-circuit tests, interpretation of curves and efficiency calculations are discussed. Graphs, diagrams.—INCO. 9855

5.3 Metallic Coatings

5.3.1 Chromium Diffusion Combats Corrosion, Heat and Wear. JACK HOLLINGUM. *Machinist* (London), **99**, 361-367 (1955) March 4.

Coating methods; properties of coatings; applications. Photographs, micrographs, graphs.—MR. 10046

5.3.1 Zinc-Coating and Painting. (In German.) W. BRACHMANN. *Metalloberfläche*, Sec. A, **8**, Nos. 10, 11, A157-A160, A172-A176 (1954) Oct., Nov.

Initially, author concisely surveys protection of iron by metallic coatings, with particular reference to application of hot-dipped coatings and their behavior in service; then discusses various paint, etc., treatments of zinc surface and pre-treatment. 37 references.—BNF. 9312

5.3.1, 1.6

Electrodeposition and Electrocrystallization of Metals. (In German.) H. FISCHER. Book, 1954, 717 pp. Springer-Verlag, Berlin/Gottigen/Heidelberg.

An up-to-date account of the theoretical background on which explanations of the physical properties of electrodeposits may be based. Theories are applied to brightness, hardness, electrical resistivity, adhesion, corrosion resistance and to the general properties of a number of individual metal and alloy deposits.—BNF. 9685

5.3.1, 8.8.3, 1.6

Electroplating Engineering Handbook. A. K. GRAHAM, Editor. Book 1955, 650 pp. Reinhold Publishing Corp., New York.

Of the two approximately equal parts, Part I, General Processing Data, contains tables of data and articles on design, preparation and cleaning, operating sequences, bath composition and operating conditions, analysis, testing, waste disposal, costing, safety, phosphating, chromating and anodizing; there is also an article on Metallurgy for the Electroplater. Part II, Engineering Fundamentals and Practice, deals with materials and construction of plant and equipment. There are 43 contributors in all and naturally some variation in quality. Nevertheless the book contains much information of practical value.—BNF. 9999

5.3.2, 7.5.2, 8.3.5

Corrosion of Tinplate by Foods Packed in Cans. D. DICKINSON. *Corrosion Technology*, **2**, Nos. 1, 2, 4-7, 49-51 (1955) Jan., Feb.

After a short account of tinning process, can production and canning, it is pointed out that the difficulty of reconciling the results of different workers over the years is mainly due to continuous changes which have taken place in tinplate, and most published work gives insufficient detail to permit of classification of type of tinplate. Second part cov-

ers corrosive effects of different packs, effects of trace elements from spraying residues, lacquers, etc.—BNF. 10026

5.3.2, 8.10.2

Iron Ore Beneficiation. F. D. DeVANEY. *Eng. Mining J.*, **156**, No. 2, 130-133 (1955) February.

Although actual production of iron ore from Lake Superior area in 1954 was lowest for any year since 1946, there was great activity in the construction of facilities for production of iron ore from taconites and other low grade materials. First commercial plant using flotation process was put into operation in 1954 at Humboldt Mine, Humboldt, Michigan. Humphreys spirals and Aerofall mill for ore grinding were put into use at Jones & Laughlin's Benson Mine in New York state. Several new mills are being constructed on the Mesabi. Use of permanent magnet separators is on the increase in heavy media and cyclone plants. Both Erie and Reserve mining companies will install cyclone classifiers for closing grinding circuit. Tests with Ni-Hard linings under severe operating conditions show that such linings are good for at least four months of continuous operation. Illustrations.—INCO. 9977

5.3.2

Several Technological Properties of Flame-Sprayed Zinc Coatings. (In German.) E. GEBHARDT AND H. D. SEGHEZZI. *Schweiz. Arch. angew. Wiss. u. Tech.*, **21**, No. 5, 162-164 (1955) May.

Report of experimental results on the mechanical properties of wire and powder-sprayed specimens as a function of specimen cross section and oxygen concentration of fuel mixture. Tables. 10 references.—BTR. 9984

5.3.2

Gaseous Metallic Diffusion. P. GALMICHE. Paper before Societe Francaise de Metallurgie. *Metal Treatment & Dyeing*, **22**, No. 113, 79-81 (1955) Feb.

Development of the technique Chromisation Brillante at ONERA, or the deposition of chromium from the gaseous phase, is described. Articles are either in contact, or near, lumps of chromium called "regeneration chromium." Slight hydrogen pressure is maintained. Photomicrographs of a nickel/chromized aluminum bronze, a bright chromized 0.3% carbon steel and surface layers of chromized Nimonic 80 are shown. Corrosion failure of refractory alloys of the Nimonic type used in aircraft turbines, was due to a localized chromium deficiency along grain boundaries, which can be prevented by chromizing as the treatment ensures a chromium enrichment along the surface. Photomicrographs.—INCO. 10009

5.3.2

Composition, Structure and Properties of Chromium Electrodeposits. (In French.) W. BLUM. *Chrome Dur* (1955), 7-18. Published by the Centre d'Information du Chrome Dur, Grand Palais, Porte C, Paris 8.

Survey of published literature. Reference is made to bibliographies published by other authors.—BNF. 9948

5.3.2

The Structure and Properties of Electrodeposited Alloys. J. W. CUTHBERTSON. Paper before Univ. Birmingham Conf. on "Structure and Properties of Electrodeposits." *Metal Ind.*, **86**, No. 16, 311-313 (1955) April 22.

Theoretical aspect of alloy deposition

is covered and the properties and structures of alloys of tin-zinc, copper-tin and tin-nickel are discussed. Alloy containing 65% tin and 35% nickel is readily electrodeposited and this coating is extremely resistant to corrosion and tarnishing. Tin-nickel diagram is characterized by a number of intermetallic compounds such as Ni_3Sn , Ni_5Sn_3 and Ni_5Sn_4 .—INCO. 9954

5.3.2

Salt Spray Corrosion of Cadmium. R. H. WOLFF. *Metal Finishing*, **53**, No. 4, 48-55 (1955) April.

Panels of cadmium plated brass and steel were exposed in a 20% salt spray cabinet with similar panels given a supplementary chromate dip. Brass panels were exposed for 160 days by which time the cadmium had begun to flake loose. Steel panels were exposed for 352 days. Cadmium plate with chromate dip was superior to the untreated plate in all stages of test including uniformity of surface appearance, suppression of white corrosion products and resistance to peeling of the plate. Adhesion of cadmium plate to brass is half as great as for cadmium to steel. Flaking of plate did not occur with chromate treated cadmium over either brass or steel. Chromated cadmium plate became dull green in appearance but did not show white corrosion during the entire test of 8000 hours. Black corrosion spots were observed on the chromate films. Chromated plate is superior in final appearance to the untreated plate. Graphs and tables.—INCO. 9903

5.3.2

Measurement of Interfacial Stress of Cobalt Deposited Electrolytically from Cobalt Fluoborate Baths. D. M. FEGREDO AND J. BALACHANDRA. *J. Sci. Ind. Res.* (India), **13B**, No. 11, 753-755 (1954) Nov.

Stress was found to fall with increasing thickness of deposit, increase in current density and increase in plating temperature, and to increase with concentration of cobalt fluoborate and with additions of gelatin and ammonium fluoborate; additions of a mixture of ammonium fluoborate and β -naphthol lowered stress. Interpretation of results difficult because of poor adhesion and cracking.—BNF. 9647

5.3.2

Use of Tin in Protection Against Corrosion. (In Italian.) S. C. BRITTON. *Metallurgical italiana*, **46**, special supplement to No. 5, 89-90 (1954) May.

Factors that determine protective qualities of various types of tin-base coatings.—MR. 9290

5.3.2

Service Results from Hard Facing. N. D. BERRICK. *Australasian Engr.*, **1954**, 50-51, Sept. 7.

Information concerning some interesting service results is given. Steel digger blades were hard faced with Cobalide 4 rod by oxyacetylene welding. This is a tubular product containing 60 percent by weight of fine granular tungsten carbides. Tests showed that Cobalide 4 extended the useful life of the blades. Mild steel top and bottom die plates were prepared and hard faced by oxyacetylene welding on the 4 edges with Cobalide 2, a chromium-cobalt-tungsten alloy. Wear rate of bulldozer cutting edges and tips has been halved since using Cobalare

1-A, an iron-chromium-manganese alloy of very high chromium carbide content.—INCO. 9307

5.3.2, 5.9.3

A Correlation of Metallurgical Hardness and Buffability. H. FAINT AND R. S. MODJESKA. *Plating*, 41, No. 12, 1422-1426 (1954) Dec.; Proc. Am. Electroplaters' Soc., 41st Ann. Convention, 1954, 262-266.

Co-operative investigation in which similar test pieces were copper plated by various plants (using 8 different baths) and were then buffed independently by three operators, the microhardness being measured before and after buffing with an Eberbach indenter unit. No definite conclusions emerged except that there was good agreement among the opera-

tors as to buffability of the deposits.—BNF. 9641

5.3.2, 2.3.4

Corrosion Behavior of Multilayer Metallic Coatings. (In Russian.) V. V. ROMANOV. *J. Applied Chem., USSR* (Zhurnal Prikladnoi Khimii), 28, No. 5, 475-479 (1955) May.

Composition of electrolytes and manner of application. Electrode potentials in relation to time in solution of sodium chloride. Potential of chromium compared to that of iron, copper, nickel, chromium multilayer coating. Polarization curves. Graphs, photograph, tables, diagram. 7 references.—BTR. 9668

5.3.2, 2.3.7

Determination of Plating Quality. G.

HOWELLS. *Corrosion Technology*, 2, No. 1, 9-12 (1955) Jan.

Plate must be free from pores and cracks, and adhesion between base metal and plating should be of high order over whole surface to avoid danger of corrosion. Other qualities such as appearance and hardness are important in some applications. Methods of testing for plating quality, including such aspects as adhesion, porosity, hardness and lustre are outlined. Potentials of various metals, including iron, steels, nickel and nickel alloys and others, in sea water, are tabulated. Tables.—INCO. 9402

5.3.2, 5.4.2

Vapor Plating. C. F. POWELL, I. E. CAMPBELL AND B. W. GONSER. Book, 1955, 158 pp. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y.

After a brief historical summary about the vapor deposition process the book opens with a 3-page table listing the metals and alloys used for vapor deposition, with physical characteristics of each. Coating apparatus is described and characteristics, adhesion and other considerations reviewed and illustrated. Chapter 2 is devoted to a discussion of vapor deposited metals, followed in succeeding chapters by carbides, nitrides, boron, silicides and oxides. References are appended after each chapter. An author and alphabetical subject index are included. 9552

5.3.2

Thick Nickel Deposits for Protection Against Corrosion in Industry. D. CHAMBAUD. Paper before Second Conf. of Cycle A.I.A.C. d'Etude des Revêtements des Metaux Contre la Corrosion, Paris, June, 1954. *Corrosion et Anti-Corrosion*, 2, 228-233 (1954) Sept-Oct.

Technique of operation, properties of nickel deposits, specific applications and some information on (French) costs are given.—INCO. 9710

5.3.2, 5.4.5

Clad and Precoated Metals. Materials and Methods Manual No. 111. J. B. CAMPBELL. *Materials & Methods*, 40, No. 6, 113-128 (1954) Dec.

A concise account covering metal coatings (pre-plating, hot-dipping, cladding or lining) and organic coatings. Appearance; surface properties; corrosion resistance; non-ferrous surface properties; fabrication and cost. A group of tables gives claddings of aluminum and alloys, copper and alloys, chromium, gold, lead and alloys, nickel and alloys, platinum and alloys, silver, stainless steel and organic coatings on a large variety of basis metals: form, functions, properties and applications are briefly indicated together in each case with the name of the American supplier.—BNF. 9709

5.3.2, 6.5

New Methods for Finishing Powder-Metal Parts. CHARLES C. COHN. *Iron Age*, 173, No. 13, 125-128 (1954).

As a result of improvements in finishing methods, plated powder-metal parts are far superior in corrosion-resistance to metal parts plated by standard methods. Thorough cleaning of internal and external porosity and proper sealing are essential. Any plated finish can be applied.—MA. 9714

5.3.3

Design for Plating. J. B. MOHLER. *Machine Design*, 27, No. 6, 165-168 (1955) June.

Specifications and practices for elec-

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troplated coatings are discussed. Variation in deposit thickness, plating corners, and engineering uses of plating are covered. Minimum thicknesses of zinc and cadmium coatings on steel, copper-nickel-chromium on copper alloys, copper-nickel-chromium on zinc alloys, and copper-lead on steel are tabulated. Four references.—INCO. 9610

5.3.3 Design Specifications for Chromium Plating Thickness. J. B. MOHLER. *Machine Design*, 27, No. 3, 161-164 (1955) Mar.

Decorative deposits and engineering applications are considered. Plating on shafts, rams and pistons, rolls and mixing equipment is discussed. Minimum thickness of electrodeposited metallic coatings (copper, nickel, copper-nickel, chromium) and typical thicknesses of electrodeposited chromium are tabulated. Some plating steps and results are illustrated. 3 references.—INCO. 9616

5.9 Surface Treatment

5.9.2 Chemical and Electrolytic Removal of Electroplated Deposits. E. MULLER. *Draht*, English Edition No. 16, 48-50 (1955) April.

Chemical methods of dissolving coating of chromium, nickel, copper, lead, tin, zinc, cadmium, etc., from iron or steel, aluminum, zinc, copper and alloys. Electrochemical methods for chromium from cast iron, steel, copper and alloys; nickel from iron, copper, brass, bronze, aluminum, zinc and alloys; copper from iron, zinc and alloys; removal of precious metal coatings.—BNF. 9649

5.9.2 Pickling Inhibitors and Accelerators. (In French.) G. ROSSI-LANDI. *Metallurgie*, 87, No. 2, 125, 127 (1955) Feb.

Role of inhibitors and accelerators in chemical cleaning of steel.—MR. 9666

5.9.2 Pickling of Thin Sheets by Means of Sonic Energy. W. MEISWINKEL. *Z. Ver. deut. Ing.*, 97, 42-46 (1955) Jan 11.

Describes work showing that use of sound can cut pickling time by a half. With 3 and 30 KC, about 30 percent of acid can be saved if sonic energy is so great (2 W per sq. cm.) that cavitation begins in pickling liquid. Steels tested included electric steel for transformers (0.08 percent nickel) and electric steel for acid-resisting steels (9.2 percent nickel, 18.3 percent chromium). At 3 KC, use was first made of vibration plate in steel with 1.5 percent nickel, 20 percent chromium, but owing to corrosion after three months, this was replaced by base plate in V4A (10 percent nickel, 19 percent chromium, 2 percent molybdenum), which was also material of descaling tank.—INCO. 9585

5.9.2 A Review of Cleanliness Tests. J. C. HARRIS. *Products Finishing*, 18, No. 11, 32-36 (1954).

Recent data on sensitivity of metal cleanliness tests are discussed. An increased sensitivity radiotracer method is described, and a comparison of the sensitivities of several methods is provided. A compilation was made of the many methods used for cleanliness, indicating the principle of action.—EL. 9746

6. MATERIALS OF CONSTRUCTION

6.1 General

6.1 What's Ahead in Engineering Materials. G. C. RIEGEL. *SAE J.*, 63, No. 2, 54-62 (1955) Feb.

Continued extensive use of iron and steel is predicted with increased use of alloys, overlays and sandwich materials to impart special characteristics. Intermediate steps such as exploitation of high silicon and high sulfur ores should be taken before leaner iron ores are considered. Alloying elements such as boron, 0.001 percent of which could replace as much as 1.5 percent nickel and 0.5 percent chromium in alloy steel, should be further investigated. Methods of conservation such as prevention of loss of steel from rusting should be practiced. Production and use of steels on basis of standard hardenability bands is another economy. New alloying practices and methods of removing impurities from metals will be developed. More effective use of metals through cladding and coating, wear prevention, and beneficial arrangement of residual stresses will be possible. Expanded usage of light metals and plastics is seen. Illustrations, graphs.—INCO. 9653

6.3 Non-Ferrous Metals and Alloys-Heavy

6.3.3 Room-Temperature Ductile Chromium. H. JOHANSEN AND G. ASAI. U. S. Bureau of Mines. Paper before Electrochem. Soc., Chicago, May 2-6, 1954. *J. Electrochem. Soc.*, 101, No. 12, 604-612 (1954) December.

Development of the effort to find room-temperature ductile chromium is reviewed. Preparation and some mechanical properties of ductile chromium are described and techniques of making brittle chromium ductile by removal of surface layers are outlined. Experiments showing the effect of certain impurities (including nickel and iron), mechanical working and heat treatment on chromium ductility are discussed. No clear explanation for the surface phenomenon was obtained. Possible future uses of ductile chromium are included. Illustrations, tables, graphs, 17 references.—INCO. 9105

6.3.3.3.5 Tensile Properties of Pure Chromium at Elevated Temperature. H. A. JOHANSEN and others. U. S. Bureau of Mines Rep. Inv. 5058, May, 1954, 8 pp.

Arc-cast chromium ingots of more than 99.9 percent purity were swaged, annealed and machined; results of tensile test from room temperature to 800 C, and metallographic study of fractures. Hot strength is not outstanding and material is very ductile.—BNF. 9116

6.3.6.3.7.2 Modern Trends in Brasses. ARTHUR H. ALLEN. *Metal Progress*, 66, No. 2, 106-110 (1954) August.

The properties of brasses and the effects of lead, tin, aluminum, silicon, manganese, iron, nickel and arsenic additions are described. Corrosion and stress-corrosion are considered. Silicon bronzes containing 1-3% silicon, 5½-7% aluminum are superior to brass in corrosive environments. The manufacture of duplex tubes by cold drawing two tubes of dif-

ferent metals simultaneously is briefly described.—MA. 9238

6.3.6.3.8.4

Anodic Behaviour of Copper in Phosphoric Acid Solutions. J. KAMECKI AND Z. ZEMBURA. *Bull. acad. polon. sci., Classe III*, 2, 31-5 (1954); *Chem. Abs.*, 48, No. 19, 11,221g (1954).

The current-voltage curve showed two breaks, more distinct in concentrated solutions. Anode passivity accompanied these breaks when the anode potential rose to about 0.5-1.8v. The curves had a saddle-like shape in those solutions in which polishing occurred. The best polishing results were obtained in a solution containing 1150g phosphoric acid.—EL. 9102

6.3.19, 7.10, 3.7.2, 3.7.3

On the Corrosion of Zinc Plates for Dry Cells. M. KAWASAKI AND A. YASUMORI. *J. Electrochem. Soc. Japan*, 22, No. 11, 597-604 (1954) Nov.

Part I. Effects of Impurities in Zinc: In the immersion test for zinc plates containing lead, cadmium and magnesium as impurities in aqueous solution of ammonium chloride, ammonium chloride-zinc chloride and ammonium chloride-zinc chloride-mercuric chloride, the weight loss of zinc plates have been measured. After the test the current efficiency of anodic dissolution of the plates into the solution has been measured. The results obtained are:

Plates with higher purity show the least weight loss, but have a tendency of pitting. An addition of suitable amounts of lead seems to decrease this tendency. The current efficiency of anodic dissolution is about 100 percent in ammonium chloride-zinc chloride and ammonium chloride-zinc chloride-mercuric chloride solutions, and is over 100 percent in ammonium chloride solution.

Part II. Effects of Surface Treatment: The following examples show that the corrosion of zinc plates is highly affected by the preliminary treatment of their surfaces. After a sufficient electro-degreasing, a zinc plate shows uniform corrosion, while the same plate gives rise to a different result by benzene-degreasing. The electro-degreasing and nitric acid-chromium trioxide treatment reveal the minute difference in corrosive behaviors of zinc plates which could not be made apparent by a benzene-degreasing. Moreover, after the electro-degreasing and nitric acid-chromium trioxide treatment, a well established relation can be observed between immersion and anodic dissolution tests in which a plate with a large weight loss in the immersion test always has a high current efficiency in the anodic dissolution test.

It is also found that Rhodin, Ibit and potassium dichromate are effective as inhibitors.

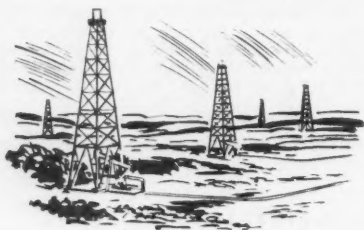
Part III: Effects of Heat Treatment: Generally speaking, after a suitable annealing the corrosion of zinc plate becomes uniform and the weight loss in an immersion test and the current efficiency of anodic dissolution of the plate become lower. By annealing zinc plates for 30 minutes at various temperatures, it is found that the minimum weight loss is observed at about 100-130 C, and the maximum at about 200 C. The amalgamation makes this tendency more remarkable.—JSPS. 9210

6.3.6.2.2.3

Corrosion Resistance of Cupronickel Alloys Containing 10 to 30 Percent

Nickel. FRANK L. LAQUE. *Corrosion*, 10, No. 11, 391-400 (1954) Nov.

Because there has been a gradual extension to industries other than the power generation industry of the use of cupronickel alloys containing 10 to 30 percent nickel the author considers it pertinent to provide information on their



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resistance to corrosives other than cooling waters. This is needed because the alloys' use in heat exchanger tubes in applications where one side is exposed to various corrosives at high temperatures makes their reaction to the product side corrosive as significant as the attack on the water side.

After outlining the basic homogeneous character of the copper-nickel alloys, the author discusses the theoretical aspects of their corrosion characteristics. Tables and figures outline results of certain tests of the alloys under various stresses and exposed to various environments.

Data collected on performance in specific service are then appended, principally in the form of tabulated information, on waters other than salt waters, ammoniacal solutions, brines, alkaline solutions, petroleum products containing hydrogen sulfide, miscellaneous petroleum products, organic compounds, chlorinated solvents, sulfuric acid, halogens and halogen compounds, paper stock suspensions. 19 references, 5 figures, 15 tables. 8529

6.3.6, 2.2.3, 1.3

Testing of Materials for Naval Shipboard Sea Water Carrying Systems—A Review. J. W. JENKINS and J. B. GUERRY. *J. Am. Soc. Naval Engrs.*, 66, No. 3, 607-639 (1954) August.

Survey of evolution, development, operation and some conclusions of the program of sea water corrosion-erosion testing carried on for the Navy at Kure Beach and Harbor Island. Development of 90-10 copper-nickel alloy with 1-1.5% iron, as a replacement for 70-30 alloy in piping, valves, condensers and other elements of Navy sea water piping systems to ensure highest performance level with maximum corrosion resistance is discussed. Current base price for 90-10 alloy is about 64.94¢ per lb. compared to 80.02¢ for 70-30, making possible a cost saving of approximately \$200,000 and a saving of about 200,000 lb. nickel, if 90-10 were used in the salt water piping systems of a CVA carrier in lieu of 70-30 copper-nickel tubing. Experimental data are tabulated. Five references.—INCO. 8539

6.3.6, 3.4.8

The Chemical Behavior of Copper. (In French and German). A. MEYER. *Pro-Metal*, 6, No. 37, 313-315 (1954) Feb.

Copper is not corroded by dry or moist air or by moist carbon dioxide. Traces of hydrogen sulfide, sulfur dioxide, ammonia, hydrogen chloride, chlorine, etc., result in gradual uniform corrosion, the products of which form a protective patina. Corrosive attack leading to damage may result from high concentrations of hydrogen sulfide or ammonia near certain chemical plants and from galvanic corrosion due to the presence of iron rust. The effects of common industrial chemicals are listed.—MA. 8696

6.3.15

Important Advantages of Titanium in the Chemical Industry. W. G. RENSHAW and PERRY R. BISH. *Corrosion*, 11, No. 1, 57-63 (1955) January.

Valuable properties of titanium are discussed with emphasis on its good resistance to specific types of corrosion, including pitting, stress and intergranular corrosion. Titanium's influence in making design problems simpler is discussed.

Passivity of titanium under oxidizing conditions resembles that of certain other metals but is distinctly different under some conditions. Some conditions which promote passivity and a stable passive state are discussed. Inhibitors are unusually effective in certain corrosive media where other passive metals are not benefited. Studies of titanium's passivating characteristics and the presence or absence of certain components in the environment may explain behavior of the metal in dry halogens and certain other media. Moist environments appear to be conducive to passivity while the reverse is often true for other metals in some of these severe applications. 8499

6.3.20, 2.3.5

Corrosion of Zirconium. I. Surface Area Determination and Sample Preparation Study. Part A. Chemical Properties of Zirconium. Part B. Determination of Surface Area Changes on Zirconium Samples. Part C. Investigation of Electro-Reduction Technique for Determining the Corrosion Rate of Zirconium. Technical Report XV. A. BURTRON JOHNSON and GEORGE RICHARD HILL. Institute for the Study of Rate Processes, Univ. of Utah. U. S. Atomic Comm. Pubn., AECU-3000, December 1, 1954, 15 pp.

A study of the chemical properties of zirconium indicates that the most satisfactory etchant for removal of films from zirconium surfaces is a solution of 3 to 10% hydrofluoric acid and 30% nitric acid in water. Preliminary measurements indicate that the electrolytic method for measuring surface areas can be used for zirconium samples. Preliminary investigations of the electro-reduction technique for determining corrosion rate of zirconium are reported.—NSA. 9200

6.3.21

Thorium Metallurgy. J. R. KEELER. *Chemical Engineering Progress*, Symposium Series, 50, No. 11, 57-61 (1954).

Thorium is prepared by the reduction of its oxide or fluoride with alkali metals; the iodide process has also been used. Thorium is ductile and can be worked by the usual processes; welding results are often erratic. Physical and mechanical properties; several alloy systems (thorium-carbon, -aluminum, -beryllium and -zirconium) are also discussed. 5 references.—BNF. 9138

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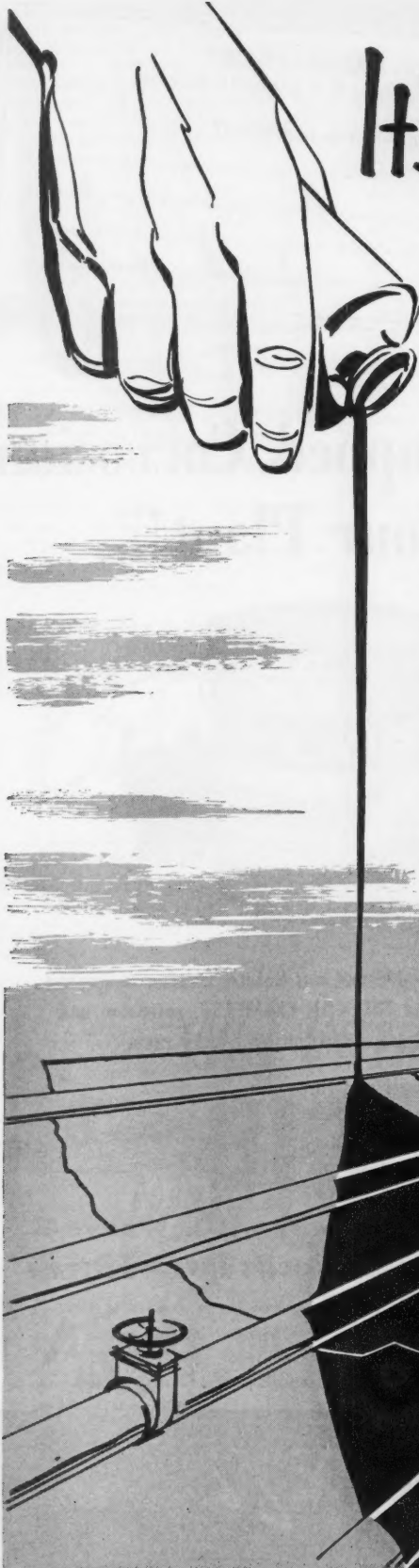
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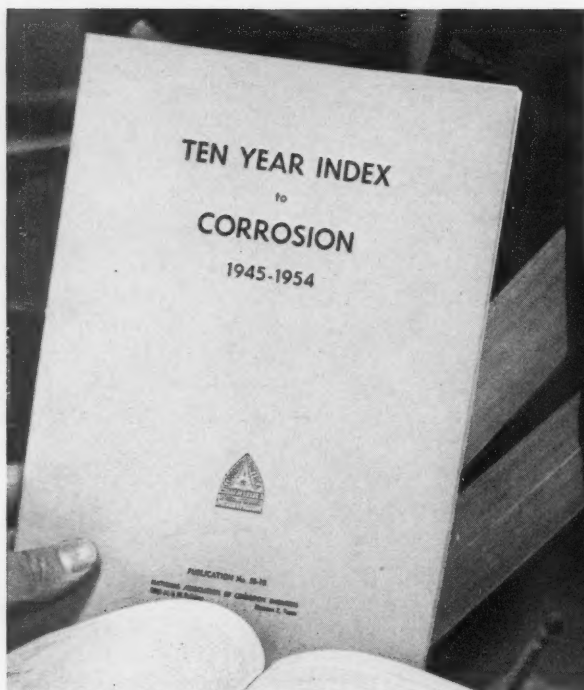
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